

DESCRIPTION

Title of Invention

METHOD OF MANUFACTURING SEMICONDUCTOR DEVICE,
5 FILM-LIKE ADHESIVE, AND DICING/DIE-BONDING
INTEGRATED FILM

Technical Field

[0001] The present disclosure relates to a method for manufacturing a
semiconductor device, a film-shaped adhesive, and a dicing/die-bonding
10 integrated film.

Background Art

[0002] Conventionally, silver paste has been mainly used for joining a
semiconductor element and a support member in a process for
manufacturing a semiconductor device. However, along with
15 miniaturization and integration of semiconductor elements in recent
years, there is a tendency that problems are likely to occur in wire
bonding due to protrusion of silver paste or inclination of semiconductor
elements. In a case where an adhesive composition is used instead of
silver paste, there are problems that it is difficult to make the thickness
20 of the adhesive layer sufficiently uniform and voids (cavities) are
generated in the adhesive layer.

[0003] In recent years, film-shaped adhesive materials have come to be
used for joining semiconductor elements and support members. For
example, Patent Literature 1 discloses a dicing/die-bonding combination
25 sheet comprising a base material, a wire-embedding layer, and an
insulating layer. When dicing is performed in a state in which the

insulating layer of this sheet and a wafer are stuck together, the semiconductor wafer and the wire-embedding layer are singulated. By thermally pressure-bonding a semiconductor element to a support member, with a wire-embedding layer interposed therebetween, the semiconductor element and the support member are joined.

[0004] As a form of a semiconductor device, stacked MCPs (multi chip packages) having a configuration in which semiconductor elements are stacked in multiple stages have been widespread. Examples of the stacked MCPs include a wire-embedded type semiconductor package and a chip-embedded type semiconductor package (see Patent Literature 2). An adhesive film used for the manufacture of a wire-embedded type semiconductor package is referred to as FOW (film over wire). An adhesive film used for the manufacture of a chip-embedded type semiconductor package is referred to as FOD (film over die). These adhesive films are required to have excellent embedding properties for wires or semiconductor elements.

Citation List

Patent Literature

[0005] Patent Literature 1: Japanese Unexamined Patent Publication No. 2007-53240

Patent Literature 2: Japanese Unexamined Patent Publication No. 2014-175459

Summary of Invention

Technical Problem

[0006] As size reduction of semiconductor elements (chips) is in progress, in a pressure-bonding step of a manufacturing process for a

semiconductor package, the pressing force per unit area tends to become excessively large. Thereby, there is a risk that a phenomenon in which an adhesive composition constituting an adhesive film protrudes in a semiconductor element (hereinafter, referred to as "bleeding") may occur, or the adhesive film may collapse excessively and cause electrical defects. Particularly, for the purpose of enhancing the embedding properties of an adhesive film (FOD) used for the manufacture of a chip-embedded type semiconductor package, when the FOD composition is changed to increase fluidity in a pressure-bonding step, bleeding occurs noticeably. For example, an adhesive composition that has protruded may creep up to the top face of the semiconductor elements, and that can be causative of an electrical defect or a wire bonding defect.

[0007] The present disclosure provides a method for manufacturing a semiconductor device by which bleeding can be sufficiently suppressed in a pressure-bonding step. Furthermore, the present disclosure provides a film-shaped adhesive and a dicing/die-bonding integrated film, both of which can be applied to this manufacturing method.

Solution to Problem

[0008] The method for manufacturing a semiconductor device according to the present disclosure includes a step of preparing a film-shaped adhesive for adhering a semiconductor element to a member for mounting the semiconductor element; and a step of pressure-bonding the semiconductor element to a surface of the member in a state that the film-shaped adhesive and the semiconductor element are stacked on the surface of the member, wherein an absolute value of

a difference between a value E_1 (mJ/m²) of surface free energy of the film-shaped adhesive and a value E_2 (mJ/m²) of surface free energy of the member is in a range of 6.0 to 10.0.

[0009] According to the above-described manufacturing method, when the absolute value of the difference between E_1 and E_2 is 6.0 or more, the film-shaped adhesive can be suppressed from excessively wetting and spreading on the member in the pressure-bonding step, and thereby bleeding can be sufficiently suppressed. On the other hand, when the absolute value of the difference between E_1 and E_2 is 10.0 or less, even when the member has a chip and/or a wire, which should be embedded, excellent embedding properties can be achieved.

[0010] By using the method of the present disclosure, a chip-embedded type semiconductor package may be manufactured, or a wire-embedded type semiconductor package may be manufactured. In the case of manufacturing a chip-embedded type semiconductor package, a structure including a substrate and a chip mounted on a surface of the substrate is prepared as the member, and a semiconductor element may be pressure-bonded to the surface of the substrate such that the chip is embedded in the film-shaped adhesive. In the case of manufacturing a wire-embedded type semiconductor package, a structure including a substrate and a wire provided on a surface of the substrate is prepared as the member, and a semiconductor element may be pressure-bonded to the surface of the substrate such that the wire is embedded in the film-shaped adhesive.

[0011] With regard to the manufacturing method of the present disclosure, a dicing/die-bonding integrated film including a film-shaped

adhesive, a tacky adhesive layer, and a base material film and having these materials laminated in this order, may be used. That is, the manufacturing method of the present disclosure may be a method including a step of preparing a dicing/die-bonding integrated film; a step of sticking together the film-shaped adhesive of the dicing/die-bonding integrated film and a wafer; a step of singulating the wafer in a state of being stuck together with the film-shaped adhesive into a plurality of semiconductor elements; a step of picking up a laminated body from the tacky adhesive layer, the laminated body including an adhesive piece formed by singulating the film-shaped adhesive and the semiconductor element; a step of pressure-bonding the laminated body to the member; and a step of curing the adhesive piece by a heating treatment.

[0012] The film-shaped adhesive according to the present disclosure is formed from a heat-curable resin composition, and the value E_1 of surface free energy is 38 to 41 mJ/m². When E_1 is in this range, the absolute value of the difference between E_1 and E_2 is likely to be in the range of 6.0 to 10.0. Meanwhile, the value E_2 of surface free energy of the member is, for example, 46 to 48 mJ/m².

[0013] In order to prepare a film-shaped adhesive having the value E_1 of surface free energy in the above-described range, for example, one or a plurality of items may be employed among the following items concerning the composition of the heat-curable resin composition constituting the film-shaped adhesive.

· The content percentage of an epoxy resin that is liquid at 25°C (based on the total mass of the epoxy resins included in the heat-curable resin composition) is set to 5% to 10% by mass.

· The heat-curable resin composition includes an epoxy resin having an alicyclic structure, a curing agent (for example, a phenol resin), and an elastomer (for example, an acrylic resin).

· The content percentage of an epoxy resin having an alicyclic structure (based on the total mass of the epoxy resins included in the heat-curable resin composition) is set to 5% to 30% by mass.

· The heat-curable resin composition includes an inorganic filler.

· The heat-curable resin composition includes a curing accelerator.

[0014] The film-shaped adhesive may constitute an adhesive film together with a base material film. That is, according to another aspect of the present disclosure, there is provided an adhesive film comprising a film-shaped adhesive and a base material film provided on one surface of the film-shaped adhesive. The film-shaped adhesive may constitute a dicing/die-bonding integrated film together with a tacky adhesive layer and a base material film. That is, according to another aspect of the present disclosure, there is provided a dicing/die-bonding integrated film comprising a film-shaped adhesive, a tacky adhesive layer, and a base material film and having these materials laminated in this order. This dicing/die-bonding integrated film may further comprise a protective film provided so as to cover the film-shaped adhesive.

Advantageous Effects of Invention

[0015] According to the present disclosure, a method for manufacturing a semiconductor device by which bleeding in a pressure-bonding step can be sufficiently suppressed, is provided. Furthermore, according to the present disclosure, a film-shaped adhesive and a dicing/die-bonding

integrated film, which can be applied to this manufacturing method, are provided.

Brief Description of Drawings

[0016] FIG. 1 is a cross-sectional view schematically illustrating an example of a semiconductor package.

FIG. 2 is a cross-sectional view schematically illustrating an example of a laminated body comprising an adhesive piece and a second semiconductor element.

FIG. 3 is a cross-sectional view schematically illustrating a process for manufacturing the semiconductor package illustrated in FIG. 1.

FIG. 4 is a cross-sectional view schematically illustrating a process for manufacturing the semiconductor package illustrated in FIG. 1.

FIG. 5 is a cross-sectional view schematically illustrating a process for manufacturing the semiconductor package illustrated in FIG. 1.

FIG. 6 is a cross-sectional view schematically illustrating a process for manufacturing the semiconductor package illustrated in FIG. 1.

FIG. 7(a) to FIG. 7(e) are cross-sectional views schematically illustrating a process for manufacturing a laminated body comprising an adhesive piece and a second semiconductor element.

Description of Embodiments

[0017] Hereinafter, embodiments of the present disclosure will be described in detail with reference to the drawings. In the following

description, identical or equivalent parts will be assigned with the same reference numeral, and any overlapping description will not be repeated. Furthermore, it should be noted that the positional relationship such as up, down, right, and left is based on the positional relationship illustrated in the drawings, unless particularly stated otherwise. In addition, the dimensional ratios of the drawings are not limited to the ratios illustrated therein. Incidentally, the description of "(meth)acryl" in the present specification means "acryl" as well as "methacryl" corresponding thereto.

[0018] <Semiconductor package>

FIG. 1 is a cross-sectional view schematically illustrating a chip-embedded type semiconductor package according to the present embodiment. A semiconductor package 100 (semiconductor device) illustrated in this diagram comprises a substrate 10; a first semiconductor element Wa (chip) mounted on a surface of the substrate 10; a first sealing layer 20 sealing the first semiconductor element Wa; a second semiconductor element Wb disposed above the first semiconductor element Wa; and a second sealing layer 40 sealing the second semiconductor element Wb.

[0019] The substrate 10 has circuit patterns 10a and 10b on the surface. From the viewpoint of suppressing warpage of the semiconductor package 100, the thickness of the substrate 10 is, for example, 90 to 180 μm and may also be 90 to 140 μm . Incidentally, the substrate 10 may be an organic substrate or a metal substrate such as a lead frame.

[0020] According to the present embodiment, the first semiconductor element Wa is a controller chip for driving the semiconductor package

100. The first semiconductor element Wa is adhered onto the circuit pattern 10a, with an adhesive 15 interposed therebetween, and is also connected to the circuit pattern 10b by means of k. The shape of the first semiconductor element Wa as viewed in a plan view is, for example, a rectangular shape (a square shape or an oblong shape). The length of one side of the first semiconductor element Wa is, for example, 6 mm or less and may also be 2 to 5 mm or 1 to 4 mm. The thickness of the first semiconductor element Wa is, for example, 10 to 150 μm and may also be 20 to 100 μm .

[0021] The second semiconductor element Wb has a larger area than the first semiconductor element Wa. The second semiconductor element Wb is mounted on the substrate 10, with the first sealing layer 20 interposed therebetween, so as to cover the entirety of the first semiconductor element Wa and a portion of the circuit pattern 10b.

The shape of the second semiconductor element Wb as viewed in a plan view is, for example, a rectangular shape (a square shape or an oblong shape). The length of one side of the second semiconductor element Wb is, for example, 20 mm or less and may also be 4 to 20 mm or 4 to 12 mm. The thickness of the second semiconductor element Wb is, for example, 10 to 170 μm and may also be 20 to 120 μm . The second semiconductor element Wb is connected to the circuit pattern 10b through a second wire 12 and is also sealed by the second sealing layer 40.

[0022] The first sealing layer 20 is formed from a cured product of an adhesive piece 20P (see FIG. 2). Incidentally, as illustrated in FIG. 2, the adhesive piece 20P and the second semiconductor element Wb have

substantially the same size. The laminated body 30 illustrated in FIG. 2 comprises the adhesive piece 20P and the second semiconductor element Wb and is also referred to as adhesive-attached semiconductor element. The laminated body 30 is produced through a dicing step and a pickup step as will be described below (see FIG. 7).

[0023] <Method for manufacturing semiconductor package>

A method for manufacturing the semiconductor package 100 will be described. First, as illustrated in FIG. 3, a structure including the substrate 10 and the first semiconductor element Wa mounted on this substrate is produced. That is, the first semiconductor element Wa is disposed on the surface of the substrate 10, with an adhesive interposed therebetween. Subsequently, the first semiconductor element Wa and the circuit pattern 10b are electrically connected with a first wire 11.

[0024] Next, as illustrated in FIG. 4, the adhesive piece 20P of the laminated body 30 that has been separately prepared is pressure-bonded to the substrate 10. Thereby, the first semiconductor element Wa and the first wire 11 are embedded in the adhesive piece 20P. In the pressure-bonding step, from the viewpoint of suppressing bleeding and achieving excellent embedding properties, the absolute value of the difference between the value E_1 (mJ/m²) of surface free energy of the adhesive piece 20P and the value E_2 (mJ/m²) of surface free energy of the substrate 10 is in the range of 6.0 to 10.0. When the absolute value of the difference between E_1 and E_2 is 6.0 or more, in the pressure-bonding step, the adhesive piece 20P can be suppressed from excessively wetting and spreading on the substrate 10, and thereby,

bleeding can be sufficiently suppressed. On the other hand, when the absolute value of the difference between E_1 and E_2 is 10.0 or less, excellent embedding properties can be achieved. The lower limit value of the absolute value of the difference between E_1 and E_2 may be 6.6 and may also be 7.0 or 7.6. The upper limit value of the absolute value of the difference between E_1 and E_2 may be 9.6 and may also be 9.0 or 8.6. Incidentally, the absolute value of the difference between E_1 and E_2 may be in the above-described range, E_1 may be larger than E_2 , or E_2 may be larger than E_1 .

[0025] The value E_1 of surface free energy of the adhesive piece 20P is, for example, 37 to 41 mJ/m² and may also be 38 to 40 mJ/m². When E_1 is in this range, the absolute value of the difference between E_1 and E_2 is easily adjusted to be in the range of 6.0 to 10.0.

[0026] The value E_2 of surface free energy of the substrate 10 is, for example, 30 to 50 mJ/m² and may also be 32 to 49 mJ/m² or 34 to 48 mJ/m². When E_2 is in this range, the absolute value of the difference between E_1 and E_2 is easily adjusted to be in the range of 6.0 to 10.0. The value of E_2 can be adjusted by applying a modification treatment as necessary to a region on the surface of the substrate 10 where the adhesive piece 20P comes into contact and the vicinity thereof. More specifically, the value of E_2 can be adjusted by applying a plasma treatment or using a solder resist that imparts polarity.

[0027] The thickness of the adhesive piece 20P may be appropriately set according to the thickness of the first semiconductor element Wa or the like, and for example, the thickness may be 20 to 200 μ m and may also be 30 to 200 μ m or 40 to 150 μ m. By adjusting the thickness of

the adhesive piece 20P to the above-described range, the interval between the first semiconductor element Wa and the second semiconductor element Wb (distance G in FIG. 5) can be sufficiently secured. The distance G is preferably, for example, 50 μm or more and may also be 50 to 75 μm or 50 to 80 μm .

[0028] It is preferable to perform pressure-bonding of the adhesive piece 20P to the substrate 10 under the conditions of, for example, 80°C to 180°C and 0.01 to 0.50 MPa for 0.5 to 3.0 seconds. Next, the adhesive piece 20P is cured by heating. It is preferable that this curing treatment is carried out under the conditions of, for example, 60°C to 175°C and 0.01 to 1.0 MPa for 5 minutes or longer. Thereby, the first semiconductor element Wa is sealed with a cured product of the adhesive piece 20P (first sealing layer 20) (see FIG. 6). The curing treatment of the adhesive piece 20P may be carried out in a pressurized atmosphere, from the viewpoint of reducing voids. The second semiconductor element Wb and the circuit pattern 10b are electrically connected by the second wire 12, and then the second semiconductor element Wb is sealed by a second sealing layer 40 to thereby complete the semiconductor package 100 (see FIG. 1).

[0029] <Method for producing adhesive-attached semiconductor element>

With reference to FIG. 7(a) to FIG. 7(e), an example of the method for producing the laminated body 30 (adhesive-attached semiconductor element) illustrated in FIG. 2 will be described. First, a dicing/die-bonding integrated film 8 (hereinafter, referred to as "film 8" in some cases) is disposed in a predetermined apparatus (not illustrated

in the diagram). The film 8 comprises a base material film 1, a tacky adhesive layer 2, and an adhesive layer 20A (film-shaped adhesive) in this order. The base material film 1 is, for example, a polyethylene terephthalate film (PET film). The semiconductor wafer W is, for example, a thin semiconductor wafer having a thickness of 10 to 100 μm . The semiconductor wafer W may be single crystal silicon or may be polycrystalline silicon, one of various ceramics, or a compound semiconductor such as gallium arsenide. Incidentally, the film 8 may also be a film further comprising a protective film (not illustrated in the diagram) provided so as to cover the adhesive layer 20A.

[0030] As illustrated in FIG. 7(a) and FIG. 7(b), the film 8 is stuck to one face of the semiconductor wafer W such that the adhesive layer 20A comes into contact with the face. This step is carried out under temperature conditions of preferably 50°C to 120°C, and more preferably 60°C to 100°C. When the temperature is 50°C or higher, satisfactory adhesiveness between the semiconductor wafer W and the adhesive layer 20A can be obtained, and when the temperature is 120°C or lower, the adhesive layer 20A is suppressed from excessively flowing in this step.

[0031] As illustrated in FIG. 7(c), the semiconductor wafer W, the tacky adhesive layer 2, and the adhesive layer 20A are diced. As a result, the semiconductor wafer W is singulated to become semiconductor elements Wb. The adhesive layer 20A is also singulated to become adhesive pieces 20P. Regarding the dicing method, a method of using a rotary blade or a laser may be mentioned. Incidentally, before dicing of the semiconductor wafer W, the semiconductor wafer W may be

thinned by grinding.

[0032] Next, in a case where the tacky adhesive layer 2 is, for example, UV-curable type, as illustrated in FIG. 7(d), the tacky adhesive layer 2 is cured by irradiating the tacky adhesive layer 2 with ultraviolet radiation, and the tacky adhesive force between the tacky adhesive layer 2 and the adhesive piece 20P is decreased. After irradiation with ultraviolet radiation, as illustrated in FIG. 7(e), the adhesive piece 20P of the laminated body 30 is detached from the tacky adhesive layer 2 by pushing up the semiconductor elements Wa with a needle 42 while separating the semiconductor elements Wa apart from each other by expanding the base material film 1 at normal temperature or under cooling conditions, and also, the laminated body 30 is suctioned with a suction collet 44 and picked up. The laminated body 30 obtained in this manner is supplied to the manufacture of the semiconductor package 100, as illustrated in FIG. 4.

[0033] <Dicing/die-bonding integrated film and method for manufacturing the same>

The dicing/die-bonding integrated film 8 illustrated in FIG. 7(a) and a method for manufacturing the same will be described. As described above, the film 8 comprises the base material film 1 (for example, a PET film), the tacky adhesive layer 2, and the adhesive layer 20A (adhesive film) in this order. The method for manufacturing the film 8 includes a step of applying a varnish of a heat-curable resin composition including an epoxy resin and the like on a film (not illustrated in the diagram); a step of forming the adhesive layer 20A by heating and drying the applied varnish at 50°C to 150°C; and a step of

sticking together the adhesive layer 20A and the tacky adhesive layer 2.

[0034] The adhesive layer 20A is formed by, for example, a step of applying a varnish including an epoxy resin, a curing agent, and an elastomer on a film; and a step of drying the coating film formed on the film. The varnish may further include an inorganic filler, a curing accelerator, and the like as necessary. The varnish can be prepared by mixing or kneading materials such as the epoxy resin in a solvent. Mixing or kneading can be carried out using dispersing machines such as a conventional stirrer, a Raikai mixer, a three-roll, and a ball mill, by appropriately combining these. Incidentally, the details of the varnish will be described below.

[0035] The film on which the varnish is applied is not particularly limited, and examples include a polyester film, a polypropylene film (OPP film or the like), a polyethylene terephthalate film, a polyimide film, a polyetherimide film, a polyether naphthalate film, and a methylpentene film.

[0036] Regarding the method of applying the varnish on the 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 may be conditions in which the solvent used is sufficiently volatilized, and for example, heating and drying can be carried out by heating at 50°C to 150°C for 1 to 30 minutes. Heating and drying may also be carried out by raising temperature stepwise at a temperature in the range of 50°C to 150°C. A laminated film of the film and the adhesive layer 20A can be obtained

by volatilizing the solvent included in the varnish by heating and drying the solvent.

[0037] The film 8 can be obtained by sticking together the laminate film obtained as described above and a dicing film (laminated body of the base material film 1 and the tacky adhesive layer 2). Examples of the base material film 1 include plastic films such as a polytetrafluoroethylene film, a polyethylene terephthalate film, a polyethylene film, a polypropylene film, a polymethylpentene film, and a polyimide film. Furthermore, the base material film 1 may be subjected to a surface treatment such as primer coating, a UV treatment, a corona discharge treatment, a polishing treatment, or an etching treatment, as necessary. The tacky adhesive layer 2 may be UV-curable type or may be pressure-sensitive type. As the tacky adhesive that forms the tacky adhesive layer 2, a tacky adhesive that is conventionally used for dicing films may be used. The thickness of the tacky adhesive layer 2 is, for example, 60 to 200 μm from the viewpoints of economic efficiency and film handleability, and the thickness may also be 70 to 170 μm .

[0038] <Varnish for forming adhesive layer>

A varnish for forming the adhesive layer 20A will be described in detail. Incidentally, the adhesive piece 20P is obtained by singulating the adhesive layer 20A, and both are formed from the same heat-curable resin composition. The adhesive layer 20A and the adhesive piece 20P are in a semi-cured (stage B) state because they are subjected to a heating treatment for volatilizing the solvent, and the adhesive layer 20A and the adhesive piece 20P enter a completely cured

product (stage C) state by a subsequent curing treatment.

[0039] A varnish for forming the adhesive layer includes an epoxy resin, a curing agent, and an elastomer as described above, and further includes an inorganic filler, a curing accelerator, and the like as necessary. The solvent for preparing the varnish is not limited as long as the solvent can uniformly dissolve, knead, or disperse the above-described various components, and for example, ketone-based solvents such as acetone, methyl ethyl ketone, methyl isobutyl ketone, and cyclohexanone; dimethylformamide, dimethylacetamide, N-methylpyrrolidone, toluene, and xylene can be used. From the viewpoint of having a high drying speed and being inexpensive, it is preferable to use methyl ethyl ketone or cyclohexanone.

[0040] (Epoxy resin)

The epoxy resin is not particularly limited in the structure; however, from the viewpoint of compatibility, it is preferable that the epoxy resin has an alicyclic structure. From the viewpoint of adjusting the value E_1 of surface free energy of the adhesive layer 20A to the range of 38 to 41 mJ/m², the content percentage of the epoxy resin having an alicyclic structure is, for example, 5% to 40% by mass and may also be 6% to 35% by mass or 7% to 34% by mass, based on the total mass of the epoxy resins included in the adhesive layer 20A. From the same point of view, the content percentage of an epoxy resin that is liquid at 25°C is, for example, 5% to 30% by mass and may also be 7% to 25% by mass or 8% to 23% by mass, based on the total mass of the epoxy resins included in the adhesive layer 20A.

[0041] Examples of a commercially available product of the epoxy

resin include dicyclopentadiene type epoxy resins HP-7200L (manufactured by DIC Corporation), HP-7200 (manufactured by DIC Corporation), XD-1000 (manufactured by Nippon Kayaku Co., Ltd.), Celloxide 2021P (manufactured by Daicel Corporation), Celloxide 20281 (manufactured by Daicel Corporation), Syna-Epoxy28 (manufactured by Synasia), bis-A type epoxy resin YD-128 (manufactured by Mitsubishi Chemical Corporation), and bis-F type epoxy resin EXA-830-CRP (manufactured by DIC Corporation). These may be used singly, or two or more kinds thereof may be used in combination.

[0042] An aromatic epoxy resin may be used as the heat-curable resin. Examples of the aromatic epoxy resin include a bisphenol A type epoxy resin, a bisphenol F type epoxy resin, a bisphenol S type epoxy resin, a phenol novolac type epoxy resin, a cresol novolac type epoxy resin, a bisphenol A novolac type epoxy resin, a bisphenol F novolac type epoxy resin, a stilbene type epoxy resin, a triazine skeleton-containing epoxy resin, a fluorene skeleton-containing epoxy resin, a triphenolphenolmethane type epoxy resin, a biphenyl type epoxy resin, a xylylene type epoxy resin, a biphenylaralkyl 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 two or more kinds thereof may be used in combination.

[0043] (Curing agent)

Examples of the curing agent include a phenol resin, an ester compound, an aromatic amine, an aliphatic amine, and an acid

anhydride. Among these, from the viewpoints of reactivity and stability over time, a phenol resin is preferred, and there is no particular limitation.

[0044] Examples of a commercially available product of the phenol resin include PHENOLITE KA and TD series manufactured by DIC Corporation, MILEX XLC- series and XL series (for example, MILEX XLC-LL) manufactured by Mitsui Chemicals, Inc., HE series (for example, HE100C-30) manufactured by AIR WATER INC., and MEHC-7800 series (for example, MEHC-7800-4S) manufactured by Meiwa Plastic Industries, Ltd. These may be used singly, or two or more kinds thereof may be used in combination. From the viewpoint of heat resistance, it is preferable that the water absorption ratio after being introduced into a constant-temperature constant-humidity tank at 85°C and 85%RH for 48 hours is 2% by mass or less, and the mass loss rate on heating at 350°C (rate of temperature increase: 5°C/min, atmosphere: nitrogen) as measured by thermal gravimetric analysis (TGA) is less than 5% by mass.

[0045] The blending amounts of the epoxy resin and the phenol resin are such that from the viewpoint of curability, the equivalent ratio of the epoxy equivalent and the hydroxyl group equivalent is preferably 0.30/0.70 to 0.70/0.30, more preferably 0.35/0.65 to 0.65/0.35, even more preferably 0.40/0.60 to 0.60/0.40, and particularly preferably 0.45/0.55 to 0.55/0.45. When the blending ratio is in the above-described range, both curability and fluidity is easily achieved at a sufficiently high level.

[0046] (Elastomer)

Examples of the elastomer include an acrylic resin, a polyester resin, a polyamide resin, a polyimide resin, a silicone resin, polybutadiene, acrylonitrile, epoxy-modified polybutadiene, maleic anhydride-modified polybutadiene, phenol-modified polybutadiene, and carboxy-modified acrylonitrile.

[0047] From the viewpoints of solubility in solvents and fluidity, an acrylic resin is preferred as the elastomer, and an acrylic resin such as an epoxy group-containing (meth)acrylic copolymer obtained by polymerizing a functional monomer having an epoxy group or a glycidyl group as a crosslinkable functional group, such as glycidyl acrylate or glycidyl methacrylate, is more preferred. Among acrylic resins, an epoxy group-containing (meth)acrylic acid ester copolymer and an epoxy group-containing acrylic rubber are preferred, and an epoxy group-containing acrylic rubber is more preferred. An epoxy group-containing acrylic rubber is a rubber having epoxy groups, which contains an acrylic acid ester as a main component and is mainly formed from a copolymer of butyl acrylate, acrylonitrile, and the like; a copolymer of ethyl acrylate, acrylonitrile, and the like; or the like. Incidentally, the acrylic resin may have not only an epoxy group but also a crosslinkable functional group such as an alcoholic or phenolic hydroxyl group, or a carboxyl group.

[0048] Examples of a commercially available product of the acrylic resin include SG-70L, SG-708-6, WS-023 EK30, SG-280 EK23, and a SG-P3 solvent-changed product (trade name, acrylic rubber, weight average molecular weight: 800000, Tg: 12°C, solvent is cyclohexanone) manufactured by Nagase ChemteX Corporation.

[0049] The glass transition temperature (T_g) of the acrylic resin is preferably -50°C to 50°C, and more preferably -30°C to 30°C. The weight average molecular weight (M_w) of the acrylic resin is preferably 100000 to 3000000, and more preferably 500000 to 2000000. When an acrylic resin having a M_w in this range is incorporated into a heat-curable resin composition, a heat-curable resin composition is easily formed into a film form, and the strength as a film form, flexibility, and tackiness are easily appropriately controlled. In addition to this, both reflow characteristics and embedding properties tend to be enhanced. Here, the M_w means a value measured by gel permeation chromatography (GPC) and converted using a calibration curve produced on the basis of polystyrene standards. Incidentally, when an acrylic resin having a narrow molecular weight distribution is used, there is a tendency that a highly elastic adhesive layer having excellent embedding properties can be formed.

[0050] The amount of the acrylic resin included in the adhesive layer 20A is preferably 20 to 200 parts by mass, and more preferably 30 to 100 parts by mass, with respect to 100 parts by mass of the sum of the epoxy resin and the epoxy resin curing agent. When the amount is in this range, the control of fluidity during molding, handleability at high temperatures, and embedding properties can be made even more favorable.

[0051] (Inorganic filler)

Examples of the inorganic filler include aluminum hydroxide, magnesium hydroxide, calcium carbonate, magnesium carbonate, calcium silicate, magnesium silicate, calcium oxide, magnesium oxide,

aluminum oxide, aluminum nitride, aluminum borate whiskers, boron nitride, crystalline silica, and amorphous silica. These may be used singly, or two or more kinds thereof may be used in combination. From the viewpoint of enhancing thermal conductivity of the adhesive layer 20A, it is preferable that the adhesive layer contains aluminum oxide, aluminum nitride, boron nitride, crystalline silica, or amorphous silica as the inorganic filler. From the viewpoint of adjusting the melt viscosity of the adhesive layer 20A and imparting thixotropic properties to the adhesive composition, it is preferable to use aluminum hydroxide, magnesium hydroxide, calcium carbonate, magnesium carbonate, calcium silicate, magnesium silicate, calcium oxide, magnesium oxide, aluminum oxide, crystalline silica, or amorphous silica.

[0052] From the viewpoint of enhancing adhesiveness, the average particle size of the inorganic filler is preferably 0.005 μm to 0.5 μm , and more preferably 0.05 to 0.3 μm . It is preferable that the surface of the inorganic filler is chemically modified, from the viewpoints of compatibility with the solvent and the resin components and the adhesive strength. A suitable material for chemically modifying the surface may be a silane coupling agent. Examples of the type of the functional group of the silane coupling agent include a vinyl group, an acryloyl group, an epoxy group, a mercapto group, an amino group, a diamino group, an alkoxy group, and an ethoxy group.

[0053] From the viewpoint of controlling the fluidity and fracturability of the adhesive layer 20A as well as the tensile modulus and adhesive force after curing, the content of the inorganic filler is preferably 10 to 90 parts by mass, and more preferably 10 to 50 parts by mass, with

respect to 100 parts by mass of the resin components of the adhesive layer 20A. When the content of the inorganic filler is 10 parts by mass or more, curing properties of the adhesive layer 20A are likely to be enhanced, and sufficient adhesive force is likely to be exhibited after curing. On the other hand, when the content of the inorganic filler is 90 parts by mass or less, fluidity of the adhesive layer 20A is likely to be sufficiently secured, and the elastic modulus can be suppressed from excessively increasing after curing.

[0054] (Curing accelerator)

Examples of the curing accelerator include an imidazole and derivatives thereof, an organic phosphorus-based compound, a secondary amine, a tertiary amine, and a quaternary ammonium salt. From the viewpoint of appropriate reactivity, an imidazole-based compound is preferred. 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 two or more kinds thereof may be used in combination.

[0055] The content of the curing accelerator in the adhesive layer 20A is preferably 0.04 to 3 parts by mass, and more preferably 0.04 to 0.2 parts by mass, with respect to 100 parts by mass of the sum of the epoxy resin and the epoxy resin curing agent. When the amount of addition of the curing accelerator is in this range, both curability and reliability can be achieved.

[0056] Thus, embodiments of the present disclosure have been described in detail; however, the present invention is not intended to be

limited to the above-described embodiments. For example, in the above-described embodiments, a chip-embedded type semiconductor package has been mentioned as an example; however, the present disclosure may also be applied to the manufacture of a wire-embedded type semiconductor package and other semiconductor devices.

Examples

[0057] Hereinafter, the present disclosure will be described in more detail by way of Examples; however, these Examples are not intended to limit the present invention.

[0058] (Examples 1 to 7 and Comparative Examples 1 and 2)

Varnishes were prepared by mixing the following materials at the blending proportions (parts by mass) shown in Tables 1 to 3. Cyclohexanone was used as a solvent, and the solid content proportion of the varnish was set to 40% by mass. The varnish was filtered through a 100-mesh filter and was also vacuum-defoamed. As a film for applying the varnish, a polyethylene terephthalate (PET) film (thickness 38 μm) that had been subjected to a release treatment was prepared. The varnish after vacuum-defoaming was applied on the face of the PET film, which had been subjected to a release treatment. The applied varnish was heated and dried in two stages at 90°C for 5 minutes and subsequently at 140°C for 5 minutes. In this manner, a laminate film comprising a PET film and a film-shaped adhesive (thickness 110 μm) in a stage B state (semi-cured state) formed on the surface of the PET film was produced as each of the adhesive films according to Examples and Comparative Examples.

[0059] [Materials]

<Epoxy resin>

· (A1) ... XD-1000: (trade name, manufactured by Nippon Kayaku Co., Ltd., cyclopentadiene type epoxy resin, alicyclic structure, solid at 25°C)

5 · (A2) ... Celloxide 2021P: (trade name, manufactured by Daicel Corporation, alicyclic structure, solid at 25°C)

· (A3) ... HP-7200L: (trade name, manufactured by DIC Corporation, cyclopentadiene type epoxy resin, alicyclic structure, solid at 25°C)

10 · (A4) ... EHPE3150 (trade name, manufactured by Daicel Corporation, alicyclic structure, solid at 25°C)

· (A5) ... VG3101L (trade name, manufactured by Printec Corporation, polyfunctional epoxy resin, solid at 25°C)

15 · (A6) ... YDCN-700-10: (trade name, manufactured by Nippon Steel & Sumikin Chemical Co., Ltd., cresol novolac type epoxy resin, solid at 25°C)

· (A7) ... EXA-830CRP: (trade name, manufactured by DIC Corporation, liquid bisphenol F type epoxy resin, liquid at 25°C)

<Curing agent>

20 · (B1) ... XLC-LL: (trade name, manufactured by Mitsui Chemicals, Inc., phenylaralkyl type phenol resin)

· (B2) ... LF-4871: (trade name, manufactured by DIC Corporation, BPA novolac type phenol resin)

25 · (B3) ... HE-100C-30: (trade name, manufactured by AIR WATER INC., phenylaralkyl type phenol resin)

<Elastomer>

· (C1) ... SG-P3 solvent-changed product (trade name, manufactured by Nagase ChemteX Corporation, acrylic rubber, weight average molecular weight: 800000, Tg: 12°C, solvent is cyclohexanone)

· (C2) ... SG-70L: (trade name, manufactured by Nagase ChemteX Corporation, acrylic rubber, weight average molecular weight 900000, acid value 5 mg KOH/g, Tg: -13°C)

<Inorganic filler>

· SC2050-HLG: (trade name, manufactured by Admatechs Company Limited, silica filler dispersion liquid, average particle size 0.50 μm)

<Curing accelerator>

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

[0060] [Evaluation of film-shaped adhesive]

For the film-shaped adhesives according to Examples and Comparative Examples, evaluation of the surface free energy and bleeding was carried out.

[0061] <Measurement of surface free energy>

The surface free energy of the film-shaped adhesives according to Examples and Comparative Examples was measured using a contact angle meter (manufactured by Kyowa Interface Science Co., Ltd.: trade name DM-701). Water, methylene iodide, and α-bromonaphthalene were used as solvents, and the contact angle between each solvent and each film-shaped adhesive was measured. The liquid droplet volume was set to 0.5 μL, and the contact angle was determined by a $\theta/2$

method. The surface free energy was calculated by means of surface free energy analysis software FAMAS (trade name, manufactured by Kyowa Interface Science Co., Ltd.) using the value of the contact angle thus obtained. The surface free energy was calculated by Kitazaki-Hata Equation. Furthermore, the surface free energy of the base material used for the following evaluation of bleeding was also similarly measured. Results are presented in Tables 1 to 3.

[0062] <Evaluation of bleeding>

First, a structure to be used for the evaluation of bleeding, the structure including a substrate and a chip mounted on the surface of the substrate, was prepared as follows. That is, a film-shaped adhesive HR9004-10 (trade name, manufactured by Hitachi Chemical Co., Ltd., thickness 10 μm) was stuck to a semiconductor wafer (diameter: 8 inches, thickness: 50 μm) at 70°C. The semiconductor wafer and the film-shaped adhesive were diced into a rectangle having a size of 2.1 $\times$ 4.8 mm to obtain an adhesive-attached chip. This adhesive-attached chip was pressure-bonded to a substrate for evaluation under the conditions of 120°C and 0.20 MPa for 2 seconds. Incidentally, a substrate (total thickness: 260 μm) having solder resist AUS308 (trade name, manufactured by TAIYO NIPPON SANSO CORPORATION) applied on the surface was used as the substrate for evaluation.

[0063] On the other hand, each of the film-shaped adhesives (thickness 110 μ) according to Examples and Comparative Examples was stuck to a semiconductor wafer (diameter: 8 inches, thickness 100 μm) at 70°C. The semiconductor wafer and the film-shaped adhesive were diced into a rectangle having a size of 6 $\times$ 12.7 mm to obtain an adhesive

piece-attached semiconductor element.

[0064] The adhesive piece-attached semiconductor element was pressure-bonded to the position where a chip was mounted in the above-described structure. The pressure-bonding conditions were set to 120°C and 0.20 MPa for 1.5 seconds. Incidentally, the semiconductor element was positioned such that the chip was embedded at the center position of the film-shaped adhesive. A sample for evaluation produced as such was observed with a microscope, and the maximum distance of the resin composition protruding from an edge of the semiconductor element (bleed amount) was measured. Results are presented in Tables 1 to 3.

[0065] [Table 1]

		Example 1	Example 2	Example 3	Example 4
Blending proportion (parts by mass)	Epoxy resin	A1	-	-	-
		A2	5	-	10
		A3	-	20	20
		A4	-	-	-
		A5	-	-	-
		A6	25	-	-
		A7	-	10	-
	Curing agent	B1	15	-	20
		B2	15	-	-
		B3	-	20	-
	Elastomer	C1	25	20	-
		C2	-	-	20
	Inorganic filler	30	30	30	30
	Curing accelerator	0.05	0.1	0.05	0.1
	Film-shaped adhesive E ₁	38.84	40.14	38.74	38.54
	Substrate E ₂	47.0	47.0	47.0	47.0
Surface free energy (mJ/m ²)			8.2	6.9	8.5
Absolute value of E ₁ - E ₂ (mJ/m ²)			60.5	59.3	56.4
Bleed amount (μm)			61.5	59.3	56.4

[0066] [Table 2]

		Example 5	Example 6	Example 7
Blending proportion (parts by mass)	Epoxy resin	A1	-	-
		A2	-	-
		A3	10	-
		A4	-	-
		A5	15	-
		A6	-	35
		A7	10	-
	Curing agent	B1	-	15
		B2	20	-
		B3	-	-
	Elastomer	C1	20	20
		C2	-	-
	Inorganic filler	30	35	30
	Curing accelerator	0.05	0.05	0.05
	Film-shaped adhesive E ₁	40.74	40.14	38.04
Surface free energy (mJ/m ²)	Substrate E ₂	47.0	47.0	47.0
Absolute value of E ₁ - E ₂ (mJ/m ²)		6.3	6.9	9.0
Bleed amount (μm)		63.9	62.6	43.0

[0067] [Table 3]

			Comparative Example 1	Comparative Example 2
Blending proportion (parts by mass)	Epoxy resin	A1	-	-
		A2	-	-
		A3	-	-
		A4	-	-
		A5	20	30
		A6	-	-
		A7	15	-
	Curing agent	B1	-	-
		B2	15	-
		B3	-	25
	Elastomer	C1	20	-
		C2	-	15
	Inorganic filler		30	30
	Curing accelerator		0.05	0.05
Surface free energy (mJ/m ²)	Film-shaped adhesive E ₁		42.94	41.54
Absolute value of E ₁ - E ₂ (mJ/m ²)	Substrate E ₂		47.0	47.0
Bleed amount (μm)			4.1	5.5
			100.4	75.8

Industrial Applicability

[0068] According to the present disclosure, there is provided a method for manufacturing a semiconductor device by which bleeding in a pressure-bonding step can be sufficiently suppressed. Furthermore, according to the present disclosure, there are provided a film-shaped adhesive and a dicing/die-bonding integrated film, which can be applied to this manufacturing method.

Reference Signs List

[0069] 1: base material film, 2: tacky adhesive layer, 8: dicing/die-bonding integrated film, 10: substrate, 20: first sealing layer (cured product of adhesive piece), 20A: adhesive layer (film-shaped adhesive), 20P: adhesive piece, 30: laminated body, 50: structure, 100: semiconductor package (semiconductor device), W: wafer, Wa: first semiconductor element (chip), Wb: second semiconductor element.

CLAIMS

1. A method for manufacturing a semiconductor device, the method comprising steps of:

preparing a film-shaped adhesive for adhering a semiconductor
5 element to a member for mounting the semiconductor element; and

pressure-bonding the semiconductor element to a surface of the member in a state that the film-shaped adhesive and the semiconductor element are stacked on the surface,

wherein an absolute value of a difference between a value E_1
10 (mJ/m^2) of surface free energy of the film-shaped adhesive and a value E_2 (mJ/m^2) of surface free energy of the member is in a range of 6.0 to 10.0.

2. The method for manufacturing a semiconductor device according to claim 1,

15 wherein the semiconductor device is a chip-embedded type semiconductor package,

the member is a structure including a substrate and a chip mounted on a surface of the substrate, and

the semiconductor element is pressure-bonded to the surface of
20 the substrate such that the chip is embedded in the film-shaped adhesive.

3. The method for manufacturing a semiconductor device according to claim 1,

25 wherein the semiconductor device is a wire-embedded type semiconductor package,

the member is a structure including a substrate and a wire

provided on a surface of the substrate, and

the semiconductor element is pressure-bonded to the surface of the substrate such that the wire is embedded in the film-shaped adhesive.

5 4. The method for manufacturing a semiconductor device according to any one of claims 1 to 3, the method comprising steps of:

 preparing a dicing/die-bonding integrated film including the film-shaped adhesive, a tacky adhesive layer, and a base material film and having these materials laminated in this order;

10 sticking together the film-shaped adhesive of the dicing/die-bonding integrated film and a wafer;

 singulating the wafer in a state of being stuck together with the film-shaped adhesive into a plurality of semiconductor elements;

 picking up a laminated body from the tacky adhesive layer, the
15 laminated body including an adhesive piece formed by singulating the film-shaped adhesive and the semiconductor element;

 pressure-bonding the laminated body to the member; and

 curing the adhesive piece by a heating treatment.

20 5. A film-shaped adhesive comprising a heat-curable resin composition,

 wherein a value E_1 of surface free energy is 38 to 41 mJ/m².

25 6. The film-shaped adhesive according to claim 5, wherein a content percentage of an epoxy resin, the epoxy resin being liquid at 25°C, is 5% to 40% by mass based on a total mass of epoxy resins included in the heat-curable resin composition.

7. The film-shaped adhesive according to claim 5 or 6, wherein the

heat-curable resin composition includes an epoxy resin having an alicyclic structure, a curing agent, and an elastomer.

8. The film-shaped adhesive according to claim 7, wherein a content percentage of the epoxy resin having an alicyclic structure is 5% to 30% by mass based on a total mass of epoxy resins included in the heat-curable resin composition.

9. The film-shaped adhesive according to claim 7 or 8, wherein the curing agent is a phenol resin.

10. The film-shaped adhesive according to any one of claims 7 to 9, wherein the elastomer is an acrylic resin.

11. The film-shaped adhesive according to any one of claims 5 to 10, wherein the heat-curable resin composition includes an inorganic filler.

12. The film-shaped adhesive according to any one of claims 5 to 11, wherein the heat-curable resin composition includes a curing accelerator.

13. An adhesive film comprising:
the film-shaped adhesive according to any one of claims 5 to 12;
and

a base material film provided on one surface of the film-shaped adhesive.

14. A dicing/die-bonding integrated film comprising the film-shaped adhesive according to any one of claims 5 to 12, a tacky adhesive layer, and a base material film and having these materials laminated in this order.

15. The dicing/die-bonding integrated film according to claim 14,

further comprising a protective film provided so as to cover the film-shaped adhesive.