

DESCRIPTION

TAPE FOR ELECTRONIC DEVICE PACKAGING

TECHNICAL FIELD

[0001] The present invention relates to a tape for electronic device packaging. More particularly, the invention relates to a tape for electronic device packaging having a metal layer.

BACKGROUND ART

[0002] In recent years, the demand for thickness reduction and size reduction of electronic equipment such as mobile telephones and laptop computers is ever increasing. Thus, in order to achieve thickness reduction and size reduction of electronic device packages such as semiconductor packages that are mounted on electronic equipment, the number of electrodes in an electronic device or a circuit board is increased, and the pitch is also made narrower. An example of such an electronic device package is a flip chip (FC) mounting package.

[0003] In regard to the flip chip mounting package, as explained above, since the number of electrodes is increased, or the pitch is narrowed, there is a problem of an increase in the amount of heat generation. Thus, as a heat dissipating structure of a flip chip mounting package, it has been suggested

to provide a metal layer on the back surface of an electronic device, with an adhesive layer interposed therebetween (see, for example, Patent Document 1).

[0004] Furthermore, in the flip chip mounting package, there are occasions in which the coefficient of linear expansion of the electronic device is greatly different from the coefficient of linear expansion of the circuit board. In this case, during the process for producing an electron device package, when an intermediate product is heated and cooled, there occur differences in the amount of expansion and the amount of shrinkage between the electronic device and the circuit board. Due to these differences, warpage occurs in the electronic device package. It has been suggested that even for a structure capable of suppressing such warpage, a metal layer should be provided on the back surface of the electronic device, with an adhesive layer interposed therebetween (see, for example, Patent Document 2).

[0005] Furthermore, in regard to the flip chip mounting package, it has also been suggested that a metal layer is provided on the back surface of an electronic device, with an adhesive layer interposed therebetween, and this metal layer is used as a protective layer for laser marking (see, for example, Patent Document 3). Furthermore, Patent Document 3 also discloses a film for flip-chip type semiconductor back surface, in which a metal layer and an adhesive layer are provided on

a pressure-sensitive adhesive layer of a pressure-sensitive adhesive tape obtained by laminating a pressure-sensitive adhesive layer on a base material.

CITATION LIST

PATENT DOCUMENT

[0006] Patent Document 1: JP 2007-235022 A

Patent Document 2: JP 5487847 B

Patent Document 3: JP 5419226 B

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0007] When the pressure-sensitive adhesive tape-integrated type film for flip-chip type semiconductor back surface described in Patent Document 3 is used, the back surface of a semiconductor wafer is stuck on the adhesive layer, the semiconductor wafer is divided into individual chips by dicing, the individually divided semiconductor chips are picked up from the pressure-sensitive adhesive tape in a state of the adhesive layer and the metal layer attached to the back surface, and the semiconductor chips are flip-chip connected to a substrate. Specifically, a semiconductor chip is brought into contact with a substrate such that the bumps formed on the circuit surface side of the semiconductor chip are brought into contact with a conductive material such as solder for joining that is adhered

to the connection pad of the substrate, and the bumps and the conductive material are melted while being pressed. Thereby, electrical conduction between the semiconductor chip and the substrate is secured, and the semiconductor chip is fixed to the adherend.

[0008] When the bumps and the conductive material are melted, if the adhesive layer is heated at once at a high temperature, there is a problem that voids are generated in the adhesive layer due to bumping of the moisture or volatile components included in the adhesive layer. In order to suppress this generation of voids, it may be considered that the adhesive layer is preliminarily cured in a state of a laminate of a metal layer, an adhesive layer and a semiconductor chip, at a temperature at which bumping of the moisture or volatile components included in the adhesive layer does not occur, before the flip chip connection.

[0009] However, when preliminary curing of the adhesive layer is performed, the heat of this process causes warpage in the laminate of a metal layer, an adhesive layer and a semiconductor chip due to the difference between the coefficients of linear expansion of the semiconductor chip and the metal layer, and there is a problem that the bumps of the semiconductor chip and the conductive material on the substrate side cannot be successfully connected.

[0010] Thus, an object of the invention is to provide a

tape for electronic device packaging which can suppress the occurrence of warpage in a laminate of a semiconductor, an adhesive layer and a semiconductor chip when the adhesive layer is preliminarily cured, and can suppress the generation of voids in the adhesive layer at the time of flip chip connection.

MEANS FOR SOLVING PROBLEM

[0011] In order to solve the problems described above, the tape for electronic device packaging according to the invention comprises a pressure-sensitive adhesive tape having a base film and a pressure-sensitive adhesive layer; a metal layer provided by lamination on a surface of the pressure-sensitive adhesive layer, the surface being on the opposite side of the base film; and an adhesive layer provided on a surface of the metal layer, the surface being on the opposite side of the pressure-sensitive adhesive layer, and intended for adhering the metal layer to the back surface of an electronic device, in which the adhesive layer has a storage modulus at 25°C of 10 GPa or less after being heated for 3 hours at 100°C, and has a curing rate of 10% to 100% when heated for 3 hours at 100°C.

[0012] In regard to the tape for electronic device packaging, it is preferable that the metal layer includes copper or aluminum.

[0013] In regard to the tape for electronic device packaging, it is preferable that the adhesive layer contains

(A) an epoxy resin, (B) a curing agent, (C) an acrylic resin or a phenoxy resin, and (D) a surface-treated inorganic filler.

[0014] Furthermore, in regard to the tape for electronic device packaging, it is preferable that the pressure-sensitive adhesive layer contains an acrylic polymer configured to include an acrylic acid ester represented by the formula: $\text{CH}_2=\text{CHCOOR}$ (wherein R represents an alkyl group having 4 to 18 carbon atoms), a hydroxyl group-containing monomer, and an isocyanate compound having a radical reactive carbon-carbon double bond in the molecule.

EFFECT OF THE INVENTION

[0015] According to the invention, when the adhesive layer is preliminarily cured, the occurrence of warpage in a laminate of a semiconductor, an adhesive layer and a semiconductor chip can be suppressed, and the generation of voids in the adhesive layer at the time of flip chip connection can be suppressed.

BRIEF DESCRIPTION OF DRAWINGS

[0016] Fig. 1 is a cross-sectional view schematically illustrating the structure of a tape for electronic device packaging according to embodiments of the invention; and

Fig. 2 is a cross-sectional view for explaining the method of using a tape for electronic device packaging according to embodiments of the invention.

MODE(S) FOR CARRYING OUT THE INVENTION

[0017] Embodiments of the invention will be explained in detail below.

[0018] Fig. 1 is a cross-sectional view illustrating a tape for electronic device packaging 10 according to embodiments of the invention. This tape for electronic device packaging 10 has a pressure-sensitive adhesive tape 13 composed of a base film 11 and a pressure-sensitive adhesive layer 12 provided on the base film 11, and provided on the pressure-sensitive adhesive layer 12 are a metal layer 14 and an adhesive layer 15 provided on the metal layer 14. The adhesive layer 15 may be provided indirectly above the metal layer 14, with a primer layer or the like interposed therebetween, in order to improve the adhesiveness between the adhesive layer 15 and the metal layer 14. The present embodiment will be explained by taking a semiconductor chip as an example of the electronic device.

[0019] In regard to the adhesive layer 15, it is preferable that the surface on the opposite side of the surface that is in contact with the metal layer 14 is protected by a separator (release liner) (not shown in the diagram). The separator has a function as a protective material that protects the adhesive layer 15 until the tape for electronic device packaging is put to practical use. Also, the separator can be used as a supporting base material when the metal layer 14 is stuck onto

the pressure-sensitive adhesive layer 12 of the pressure-sensitive adhesive tape 13 during the production process for the tape for electronic device packaging 10.

[0020] The pressure-sensitive adhesive tape 13, the metal layer 14, and the adhesive layer 15 may be cut in advance into a predetermined shape (precut) according to the process or apparatus to be used. Furthermore, the tape for electronic device packaging 10 of the invention may have a shape that has been cut for each sheet of semiconductor wafer W1, or may have a shape obtained by winding a long sheet composed of a plurality of tapes that has been cut for each sheet of semiconductor wafer W1, into a roll. The various constituent elements will be explained below.

[0021] <Base film 11>

Regarding the base film 11, any conventionally known base film can be used without any particular limitations; however, in a case in which a radiation-curable material is used as the pressure-sensitive adhesive layer 12 that will be described below, it is preferable to use a base film having radiation transmissibility.

[0022] Examples of the material include homopolymers or copolymers of α -olefins, such as polyethylene, polypropylene, an ethylene-propylene copolymer, polybutene-1, poly-4-methylpentene-1, an ethylene-vinyl acetate copolymer, an ethylene-ethyl acrylate copolymer, an ethylene-methyl

acrylate copolymer, an ethylene-acrylic acid copolymer, and an ionomer, or mixtures thereof; thermoplastic elastomers such as polyurethane, a styrene-ethylene-butene or pentene-based copolymer, and a polyamide-polyol copolymer; and mixtures thereof. The base film 11 may be a mixture of two or more materials selected from the group of these materials, or may be a single-layered product or a multilayer product of these materials.

[0023] The thickness of the base film 11 is not particularly limited, and may be appropriately set. However, the thickness is preferably 50 to 200 μm .

[0024] In order to enhance the adhesiveness between the base film 11 and the pressure-sensitive adhesive layer 12, the surface of the base film 11 may be subjected to a chemical or physical surface treatment such as a chromic acid treatment, exposure to ozone, exposure to flame, exposure to a high voltage electric shock, or an ionizing radiation treatment.

[0025] According to the present embodiment, the pressure-sensitive adhesive layer 12 is provided directly on the base film 11; however, the pressure-sensitive adhesive layer 12 may be provided indirectly, with a primer layer for providing adhesiveness, an anchor layer for enhancing cutting properties at the time of dicing, a stress relaxation layer, an antistatic layer or the like, interposed therebetween.

[0026] <Pressure-sensitive adhesive layer 12>

The resin that is used for the pressure-sensitive adhesive layer 12 is not particularly limited, and a chlorinated polypropylene resin, an acrylic resin, a polyester resin, a polyurethane resin, an epoxy resin and the like, which are known to be used for pressure-sensitive adhesives, can be used. However, an acrylic pressure-sensitive adhesive that uses an acrylic polymer as a base polymer is preferred.

[0027] Examples of the acrylic polymer include acrylic polymers that use one kind or two or more kinds of a (meth)acrylic acid alkyl ester (for example, a linear or branched alkyl ester having an alkyl group with 1 to 30 carbon atoms, and particularly 4 to 18 carbon atoms, such as a methyl ester, an ethyl ester, a propyl ester, an isopropyl ester, a butyl ester, an isobutyl ester, a s-butyl ester, a t-butyl ester, a pentyl ester, an isopentyl ester, a hexyl ester, a heptyl ester, an octyl ester, a 2-ethylhexyl ester, an isooctyl ester, a nonyl ester, a decyl ester, an isodecyl ester, an undecyl ester, a dodecyl ester, a tridecyl ester, a tetradecyl ester, a hexadecyl ester, an octadecyl ester, or an eicosyl ester); and a (meth)acrylic acid cycloalkyl ester (for example, a cyclopentyl ester or a cyclohexyl ester), as monomer components. Here, the term (meth)acrylic acid ester refers to acrylic acid ester and/or methacrylic acid ester, and the term (meth) as used herein has the same meaning in all cases.

[0028] The acrylic polymer may include a unit

corresponding to another monomer component that is copolymerizable with the (meth)acrylic acid alkyl ester or cycloalkyl ester as necessary, for the purpose of modifying the cohesive force, heat resistance and the like of the polymer. Examples of such a monomer component include carboxyl group-containing monomers such as acrylic acid, methacrylic acid, carboxyethyl (meth)acrylate, carboxypentyl (meth)acrylate, itaconic acid, maleic acid, fumaric acid, and crotonic acid; acid anhydride monomers such as maleic anhydride and itaconic anhydride; hydroxyl group-containing monomers such as 2-hydroxyethyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate, 4-hydroxybutyl (meth)acrylate, 6-hydroxyhexyl (meth)acrylate, 8-hydroxyoctyl (meth)acrylate, 10-hydroxydecyl (meth)acrylate, 12-hydroxylauryl (meth)acrylate, and (4-hydroxymethylcyclohexyl)methyl (meth)acrylate; sulfonic acid group-containing monomers such as styrenesulfonic acid, allylsulfonic acid, 2-(meth)acrylamido-2-methylpropanesulfonic acid, (meth)acrylamidopropanesulfonic acid, sulfopropyl (meth)acrylate, and (meth)acryloyloxynaphthalenesulfonic acid; phosphoric acid group-containing monomers such as 2-hydroxyethylacryloyl phosphate; acrylamide, and acrylonitrile. These copolymerizable monomer components can be used singly or as mixtures of two or more kinds thereof. The amount of use of these copolymerizable monomers is preferably

40% by weight or less of the total amount of the monomer components.

[0029] Furthermore, since the acrylic polymer is crosslinked, the acrylic polymer may also include a polyfunctional monomer or the like as necessary, as a monomer component for copolymerization. Examples of such a polyfunctional monomer include hexanediol di(meth)acrylate, (poly)ethylene glycol di(meth)acrylate, (poly)propylene glycol di(meth)acrylate, neopentyl glycol di(meth)acrylate, pentaerythritol di(meth)acrylate, trimethylolpropane tri(meth)acrylate, pentaerythritol tri(meth)acrylate, dipentaerythritol hexa(meth)acrylate, epoxy (meth)acrylate, polyester (meth)acrylate, and urethane (meth)acrylate. These polyfunctional monomers can also be used singly or as mixtures of two or more kinds thereof. The amount of use of the polyfunctional monomer is preferably 30% by weight or less of the total amount of the monomer components, from the viewpoint of pressure-sensitive adhesion characteristics and the like.

[0030] Production of the acrylic polymer can be carried out by, for example, applying an appropriate method such as a solution polymerization method, an emulsion polymerization method, a bulk polymerization method or a suspension polymerization method to one kind of component monomer or a mixture of two or more kinds of component monomers. In regard to the pressure-sensitive adhesive layer 12, a composition with

suppressed inclusion of low molecular weight substances is preferred from the viewpoint of preventing contamination of wafers, and from this point of view, it is preferable to use an acrylic polymer having a weight average molecular weight of 300,000 or more, and particularly 400,000 to 3,000,000, as a main component. Therefore, the pressure-sensitive adhesive can be of an appropriately crosslinked type based on an internal crosslinking method, an external crosslinking method or the like.

[0031] Furthermore, in order to enhance the pick-up properties by controlling the crosslinking density of the pressure-sensitive adhesive layer 12, for example, an adequate method such as a method of performing a crosslinking treatment using an appropriate external crosslinking agent such as a polyfunctional isocyanate-based compound, a polyfunctional epoxy-based compound, a melamine-based compound, a metal salt-based compound, a metal chelate-based compound, an amino resin-based compound, or a peroxide; or a method of mixing low molecular weight compounds each having two or more carbon-carbon double bonds, and performing a crosslinking treatment by irradiation with energy rays or the like, can be employed. In the case of using an external crosslinking agent, the amount of use thereof is appropriately determined based on the balance between the crosslinking agent and the base polymer to be crosslinked, and also based on the use applications as

a pressure-sensitive adhesive. Generally, it is preferable that the external crosslinking is incorporated in an amount of about 10 parts by weight or less, and more preferably 0.1 parts by weight to 10 parts by weight, with respect to 100 parts by weight of the base polymer. For the pressure-sensitive adhesive, if necessary, various additives such as a tackifier and an aging preventing agent may also be used in addition to the components described above, from the viewpoint of preventing deterioration or the like.

[0032] As the pressure-sensitive adhesive that constitutes the pressure-sensitive adhesive layer 12, a radiation-curable pressure-sensitive adhesive is suitable. An example of the radiation-curable pressure-sensitive adhesive may be an addition type radiation-curable pressure-sensitive adhesive obtained by incorporating a radiation-curable monomer component or a radiation-curable oligomer component to the pressure-sensitive adhesive described above.

[0033] Examples of the radiation-curable monomer component to be incorporated include urethane (meth)acrylate, trimethylolpropane tri(meth)acrylate, tetramethylolmethane tetra(meth)acrylate, pentaerythritol tri(meth)acrylate, pentaerythritol tetra(meth)acrylate, dipentaerythritol monohydroxypenta(meth)acrylate, dipentaerythritol hexa(meth)acrylate, and 1,4-butanediol di(meth)acrylate.

These monomer components can be used singly or in combination of two or more kinds thereof.

[0034] Furthermore, examples of the radiation-curable oligomer component include various oligomers such as urethane-based, polyether-based, polyester-based, polycarbonate-based, and polybutadiene-based oligomers, and an oligomer having a molecular weight in the range of about 100 to 30,000 is suitable. Regarding the amount of incorporation of the radiation-curable monomer component or oligomer component, an amount that can lower the pressure-sensitive adhesive force of the pressure-sensitive adhesive layer can be appropriately determined depending on the kind of the pressure-sensitive adhesive layer. Generally, the amount of incorporation is, for example, 5 parts by weight to 500 parts by weight, and preferably about 70 parts by weight to 150 parts by weight, with respect to 100 parts by weight of the base polymer such as the acrylic polymer that constitutes the pressure-sensitive adhesive.

[0035] Regarding the radiation-curable pressure-sensitive adhesive, there may also be mentioned an intrinsic type radiation-curable pressure-sensitive adhesive obtained by using a polymer having a carbon-carbon double bond in a side chain or the main chain of the polymer or at the main chain terminals as the base polymer, in addition to the addition type radiation-curable pressure-sensitive adhesive. An

intrinsic type radiation-curable pressure-sensitive adhesive does not need to contain an oligomer component and the like, which are low molecular weight components, or do not include many oligomer component and the like. Therefore, a pressure-sensitive adhesive layer having a stable layer structure can be formed, without allowing oligomer components and the like to migrate around in the pressure-sensitive adhesive over time, and this is preferable.

[0036] Regarding the base polymer having a carbon-carbon double bond, any polymer having a carbon-carbon double bond and having pressure-sensitive adhesiveness can be used without any particular limitations. It is preferable that such a base polymer has an acrylic polymer as the basic skeleton. Examples of the acrylic polymer basic skeleton include the acrylic polymers listed above as examples.

[0037] The method for introducing a carbon-carbon double bond into an acrylic polymer is not particularly limited, and various methods can be employed. However, it is advantageous to introduce a carbon-carbon double bond into a polymer side chain, in view of molecular design. For example, a method of copolymerizing in advance a monomer having a functional group into an acrylic polymer, and then subjecting the copolymerization product to a condensation or addition reaction with a compound having a carbon-carbon double bond and a functional group that is capable of reacting with the

aforementioned functional group, while maintaining the radiation-curability of the carbon-carbon double bond, may be employed.

[0038] Examples of combinations of these functional groups include a combination of a carboxylic acid group and an epoxy group, a combination of a carboxylic acid group and an aziridyl group, and a combination of a hydroxyl group and an isocyanate group. Among these combinations of functional groups, a combination of a hydroxyl group and an isocyanate group is suitable, from the viewpoint of the ease of tracing the reaction. As long as a combination which allows production of the acrylic polymer having a carbon-carbon double bond by the combination of these functional groups is employed, the functional group may be on any side of the acrylic polymer and the compound. However, in the preferred combination described above, it is suitable that the acrylic polymer has a hydroxyl group, and the compound has an isocyanate group. In this case, examples of the isocyanate compound having a carbon-carbon double bond include methacryloyl isocyanate, 2-methacryloyloxyethyl isocyanate, and m-isopropenyl- α,α -dimethylbenzyl isocyanate. Furthermore, as the acrylic polymer, acrylic polymers copolymerized with the hydroxyl group-containing monomers described above or ether-based compounds such as 2-hydroxyethyl vinyl ether, 4-hydroxybutyl vinyl ether, and diethylene glycol monovinyl

ether, are used.

[0039] Regarding the intrinsic type radiation-curable pressure-sensitive adhesive, the base polymer having a carbon-carbon double bond (particularly, an acrylic polymer) can be used alone; however, a photopolymerizable compound such as the radiation-curable monomer component or oligomer component described above may also be incorporated to the extent that the characteristics are not deteriorated. The amount of incorporation of the photopolymerizable compound is usually within the range of 30 parts by weight or less, and preferably within the range of 0 to 10 parts by weight, with respect to 100 parts by weight of the base polymer.

[0040] It is preferable that a photopolymerization initiator is incorporated into the radiation-curable pressure-sensitive adhesive, in a case in which the pressure-sensitive adhesive is cured by ultraviolet radiation or the like.

[0041] Among the acrylic polymers described above, particularly acrylic polymer A, which is configured to include an acrylic acid ester represented by the formula: $\text{CH}_2=\text{CHCOOR}$ (wherein R represents an alkyl group having 4 to 18 carbon atoms), a hydroxyl group-containing monomer, and an isocyanate compound having a radical reactive carbon-carbon double bond in the molecule, is preferred.

[0042] If the alkyl group of the acrylic acid alkyl ester

has fewer than 4 carbon atoms, the acrylic acid ester has high polarity and excessively large peeling force, and the pick-up properties may be deteriorated. On the other hand, if the alkyl group of the acrylic acid alkyl ester has more than 18 carbon atoms, the glass transition temperature of the pressure-sensitive adhesive layer 12 becomes too high, thereby the adhesion characteristics at normal temperature are deteriorated, and as a result, detachment of the metal layer 15 may occur at the time of dicing.

[0043] The acrylic polymer A may also include a unit corresponding to another monomer component, if necessary.

[0044] For the acrylic polymer A, an isocyanate compound having a radical reactive carbon-carbon double bond is used. That is, it is preferable that the acrylic polymer has a configuration in which a double bond-containing isocyanate compound is added, by an addition reaction, to a polymer obtained from a monomer composition of the acrylic acid ester or the hydroxyl group-containing monomer. Therefore, it is preferable that the acrylic polymer has a radical reactive carbon-carbon double bond in the molecular structure. Thereby, an active energy ray-curable pressure-sensitive adhesive layer (ultraviolet-curable pressure-sensitive adhesive layer or the like) that is cured when irradiated with active energy radiation (ultraviolet radiation or the like) can be provided, and the peeling force between the metal layer 15 and the

pressure-sensitive adhesive layer 12 can be reduced.

[0045] Examples of the double bond-containing isocyanate compound include methacryloyl isocyanate, acryloyl isocyanate, 2-methacryloyloxyethyl isocyanate, 2-acryloyloxyethyl isocyanate, and m-isopropenyl- α,α -dimethylbenzyl isocyanate. The double bond-containing isocyanate compounds can be used singly or in combination of two or more kind thereof.

[0046] Furthermore, in the active energy ray-curable pressure-sensitive adhesive, an external crosslinking agent can be appropriately used in order to adjust the pressure-sensitive adhesive force before the irradiation with active energy radiation, or the pressure-sensitive adhesive force after the irradiation with active energy radiation. Regarding a specific means for an external crosslinking method, a method of adding a so-called crosslinking agent such as a polyisocyanate compound, an epoxy compound, an aziridine compound, or a melamine-based crosslinking agent, and causing the pressure-sensitive adhesive to react, may be used. In the case of using an external crosslinking agent, the amount of use of the agent is appropriately determined on the basis of the balance between the crosslinking agent and the base polymer to be crosslinked, and on the basis of the use applications as the pressure-sensitive adhesive. The amount of use of the external crosslinking agent is generally 20 parts by weight or less (preferably 0.1 parts by weight to 10 parts by weight) with

respect to 100 parts by weight of the base polymer. Furthermore, if necessary, various conventionally known additives such as a tackifier, an aging preventing agent and a foaming agent, may also be incorporated into the active energy ray-curable pressure-sensitive adhesive, in addition to the components described above.

[0047] The thickness of the pressure-sensitive adhesive layer 12 is not particularly limited and can be appropriately determined; however, the thickness is generally about 5 to 200 μm . The pressure-sensitive adhesive layer 12 may be composed of a single layer, or may be composed of multiple layers.

[0048] <Metal layer 14>

 The metal that constitutes the metal layer 14 is not particularly limited, and it is preferable that the metal is, for example, at least one metal selected from the group consisting of stainless steel, aluminum, iron, titanium, tin, nickel and copper, from the viewpoint of heat dissipation properties and from the viewpoint of preventing warpage in the electronic device package. Among these, it is particularly preferable that the metal layer 14 includes copper, from the viewpoint of obtaining high thermal conductivity and a heat dissipation effect. Furthermore, from the viewpoint of preventing warpage in the electronic device package 8, it is particularly preferable that the metal layer 14 includes aluminum.

[0049] The thickness of the metal layer 14 can be appropriately determined in consideration of the heat dissipation properties, prevention of warpage in the electronic device package, processability and the like, and the thickness is usually in the range of 2 to 200 μm . When the thickness of the metal layer 14 is 200 μm or less, the winding processing is facilitated, and if the metal layer is 50 μm or less, it is preferable from the viewpoint that this thickness can contribute to thickness reduction of the electronic device package. Meanwhile, from the viewpoint of heat dissipation properties, the thickness needs to be 2 μm or more at the minimum.

[0050] Regarding such a metal layer 14, a metal foil can be used, and the metal foil may be an electrolytic foil, or may be a rolled foil.

[0051] <Adhesive layer 15>

 The adhesive layer 15 is a layer obtained by processing an adhesive into a film in advance.

[0052] The adhesive layer 15 is formed from at least a thermosetting resin, and it is preferable that the adhesive layer is formed from at least a thermosetting resin and a thermoplastic resin.

[0053] Examples of the thermoplastic resin include natural rubber, butyl rubber, isoprene rubber, chloroprene rubber, an ethylene-vinyl acetate copolymer, an ethylene-acrylic acid copolymer, an ethylene-acrylic acid

ester copolymer, a polybutadiene resin, a polycarbonate resin, a thermoplastic polyimide resin, a polyamide resin such as 6-nylon or 6,6-nylon, a phenoxy resin, an acrylic resin, a saturated polyester resin such as PET (polyethylene terephthalate) or PBT (polybutylene terephthalate), a polyamideimide resin, and a fluororesin. The thermoplastic resins can be used singly, or two or more kinds thereof can be used in combination. Among these thermoplastic resins, an acrylic resin is particularly preferred from the viewpoint of having less ionic impurities and having excellent stress relaxation performance; and a phenoxy resin is particularly preferred from the viewpoint of achieving a balance between flexibility and strength and having high toughness, because the resins make it easier to secure reliability of semiconductor elements from the respective viewpoints.

[0054] The acrylic resin is not particularly limited, and a polymer containing, as components, one kind or two or more kinds of acrylic acid or methacrylic acid esters each having a linear or branched alkyl group having 30 or fewer carbon atoms (preferably 1 to 18 carbon atoms, more preferably 6 to 10 carbon atoms, and particularly preferably 8 or 9 carbon atoms) may be used. That is, according to the invention, the acrylic resin is meant to also include a methacrylic resin in a broad sense. Examples of the alkyl group include a methyl group, an ethyl group, a propyl group, an isopropyl group, a n-butyl group, a

t-butyl group, an isobutyl group, a pentyl group, an isopentyl group, a hexyl group, a heptyl group, a 2-ethylhexyl group, an octyl group, an isooctyl group, a nonyl group, an isononyl group, a decyl group, an isodecyl group, an undecyl group, a dodecyl group (lauryl group), a tridecyl group, a tetradecyl group, a stearyl group, and an octadecyl group.

[0055] Furthermore, the other monomer for forming the acrylic resin (monomer other than an alkyl ester of acrylic acid or methacrylic acid with an alkyl group having 30 or fewer carbon atoms) is not particularly limited, and examples include carboxyl group-containing monomers such as acrylic acid, methacrylic acid, carboxyethyl acrylate, carboxypentyl acrylate, itaconic acid, maleic acid, fumaric acid, or crotonic acid; acid anhydride monomers such as maleic anhydride or itaconic anhydride; hydroxyl group-containing monomers such as 2-hydroxyethyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate, 4-hydroxybutyl (meth)acrylate, 6-hydroxyhexyl (meth)acrylate, 8-hydroxyoctyl (meth)acrylate, 10-hydroxydecyl (meth)acrylate, 12-hydroxylauryl (meth)acrylate, or (4-hydroxymethylcyclohexyl)-methyl acrylate; sulfonic acid group-containing monomers such as styrenesulfonic acid, allylsulfonic acid, 2-(meth)acrylamido-2-methylpropanesulfonic acid, (meth)acrylamidopropanesulfonic acid, sulfopropyl (meth)acrylate, or (meth)acryloyloxynaphthalenesulfonic acid;

or phosphoric acid group-containing monomers such as 2-hydroxyethylacryloyl phosphate. Meanwhile, the term (meth)acrylic acid refers to acrylic acid and/or methacrylic acid, and the term (meth) of the invention means the same in all cases.

[0056] Examples of the thermosetting resin include, in addition to an epoxy resin and a phenolic resin, an amino resin, an unsaturated polyester resin, a polyurethane resin, a silicone resin, and a thermosetting polyimide resin. The thermosetting resins can be used singly or in combination of two or more kinds thereof. Regarding the thermosetting resin, an epoxy resin having a smaller content of ionic impurities that corrode semiconductor elements is particularly suitable. Furthermore, a phenolic resin can be suitably used as a curing agent for an epoxy resin.

[0057] The epoxy resin is not particularly limited, and for example, bifunctional epoxy resins or polyfunctional epoxy resins, such as a bisphenol A type epoxy resin, a bisphenol F type epoxy resin, a bisphenol S type epoxy resin, a brominated bisphenol A type epoxy resin, a hydrogenated bisphenol A type epoxy resin, a bisphenol AF type epoxy resin, a biphenyl type epoxy resin, a naphthalene type epoxy resin, a fluorene type epoxy resin, a phenol-novolac type epoxy resin, an orthocresol-novolac type epoxy resin, a trishydroxyphenylmethane type epoxy resin, and a

tetraphenylolthane type epoxy resin; or epoxy resins such as a hydantoin type epoxy resin, a trisglycidyl isocyanurate type epoxy resin, or a glycidylamine type epoxy resin, can be used.

[0058] As the epoxy resin, among the examples, a novolac type epoxy resin, a biphenyl type epoxy resin, a trishydroxyphenylmethane type epoxy resin, and a tetraphenylolthane type epoxy resin are particularly preferred. It is because these epoxy resins are highly reactive with phenolic resins as curing agents, and have excellent heat resistance or the like.

[0059] The phenolic resin acts as a curing agent for an epoxy resin, and examples thereof include novolac type phenolic resins such as a phenol novolac resin, a phenol aralkyl resin, a cresol novolac resin, a tert-butylphenol novolac resin, and a nonylphenol novolac resin; resol type phenolic resins; and polyoxystyrene such as polyparaoxystyrene. The phenolic resins can be used singly or in combination of two or more kinds thereof. Among these phenolic resins, a phenol novolac resin and a phenol aralkyl resin are particularly preferred. It is because the connection reliability of semiconductor devices can be enhanced.

[0060] In regard to the mixing ratio between the epoxy resin and the phenolic resin, it is suitable to mix the epoxy resin with the phenolic resin such that the amount of hydroxyl groups in the phenolic resin per equivalent of epoxy groups in

the epoxy resin component would be, for example, 0.5 equivalents to 2.0 equivalents, and more suitably 0.8 equivalents to 1.2 equivalents. That is, if the mixing ratio of the two components is not in the range described above, the curing reaction does not proceed sufficiently, and the characteristics of the epoxy resin cured product are easily deteriorated.

[0061] A thermosetting accelerating catalyst for the epoxy resin and the phenolic resin may also be used. The thermosetting accelerating catalyst is not particularly limited, and can be appropriately selected for use from among known thermosetting accelerating catalysts. The thermosetting accelerating catalysts can be used singly or in combination of two or more kinds thereof. As the thermosetting accelerating catalyst, for example, an amine-based curing accelerating agent, a phosphorus-based curing accelerating agent, an imidazole-based curing accelerating agent, a boron-based curing accelerating agent, and a phosphorus-boron-based curing accelerating agent can be used.

[0062] Regarding the curing agent for an epoxy resin, it is preferable to use a phenolic resin as explained above; however, known curing agents such as imidazoles, amines, and acid anhydrides can also be used.

[0063] It is important that the adhesive layer 15 has adhesiveness (stickiness) to the back surface (surface where circuits are not formed) of a semiconductor wafer. Thus, in

order to crosslink the adhesive layer 15 in advance to a certain extent, a polyfunctional compound that reacts with the functional group at the molecular chain terminal of the polymer or the like may also be added as a crosslinking agent. Thereby, the adhesion characteristics at high temperature can be enhanced, and an improvement of heat resistance can be promoted.

[0064] Regarding the crosslinking agent, any known crosslinking agent can be used without any particular limitations. Specific examples thereof include an isocyanate-based crosslinking agent, an epoxy-based crosslinking agent, a melamine-based crosslinking agent, a peroxide-base crosslinking agent, a urea-based crosslinking agent, a metal alkoxide-based crosslinking agent, a metal chelate-based crosslinking agent, a metal salt-based crosslinking agent, a carbodiimide-based crosslinking agent, an oxazoline-based crosslinking agent, an aziridine-based crosslinking agent, and an amine-based crosslinking agent. As the crosslinking agent, an isocyanate-based crosslinking agent or an epoxy-based crosslinking agent is suitable. The crosslinking agents can be used singly or in combination of two or more kinds thereof.

[0065] According to the invention, it is also possible to apply a crosslinking treatment by irradiation with an electron beam, ultraviolet radiation or the like, instead of using a crosslinking agent or simultaneously with the use of a

crosslinking agent.

[0066] If necessary, other additives can be incorporated as appropriate into the adhesive layer 15. Examples of the other additives include a filler, a flame retardant, a silane coupling agent, an ion trapping agent, an extending agent, an aging preventing agent, an oxidation preventing agent, and a surfactant.

[0067] The filler may be any one of an inorganic filler and an organic filler; however, an inorganic filler is suitable. By incorporating a filler such as an inorganic filler, enhancement of thermal conductivity of the adhesive layer 15, regulation of the elastic modulus, and the like can be promoted. Examples of the inorganic filler include ceramics such as silica, clay, gypsum, calcium carbonate, barium sulfate, alumina, beryllium oxide, silicon carbide, aluminum nitride, and silicon nitride; metals such as aluminum, copper, silver, gold, nickel, chromium, lead, tin, zinc, palladium, and solder, or alloys; and various inorganic powders formed from carbon and the like. The fillers can be used singly or in combination of two or more kinds thereof. Regarding the filler, among them, silica or alumina is suitable, and as the silica, fused silica is particularly suitable. The average particle size of the inorganic filler is preferably in the range of 0.001 μm to 80 μm . The average particle size of the inorganic filler can be measured using, for example, a laser diffraction type particle

size distribution analyzer.

[0068] The amount of incorporation of the filler (particularly, inorganic filler) is preferably 98% by weight or less (0% by weight to 98% by weight) with respect to the organic resin components. Particularly, in the case of silica, the amount of incorporation is suitably 0% by weight to 70% by weight, and in the case of a functional inorganic filler for thermal conduction or electrical conduction, the amount of incorporation is suitably 10% by weight to 98% by weight.

[0069] Examples of the flame retardant include antimony trioxide, antimony pentoxide, and a brominated epoxy resin. The flame retardants can be used singly or in combination of two or more kinds thereof. Examples of the silane coupling agent include β -(3,4-epoxycyclohexyl)ethyltrimethoxysilane, γ -glycidoxypropyltrimethoxysilane, and γ -glycidoxypropylmethyldiethoxysilane. The silane coupling agents can be used singly or in combination of two or more kinds thereof. Examples of the ion trapping agent include hydrotalcites and bismuth hydroxide. The ion trapping agents can be used singly or in combination of two or more kinds thereof.

[0070] It is particularly preferable, from the viewpoints of adhesiveness and reliability, that the adhesive layer 15 contains (A) an epoxy resin, (B) a curing agent, (C) an acrylic resin or a phenoxy resin, and (D) a surface-treated inorganic filler.

[0071] By using the (A) epoxy resin, high adhesiveness, water resistance and heat resistance are obtained. As the epoxy resin, the above-mentioned known epoxy resins can be used. Regarding the (B) curing agent, any known curing agent can be used.

[0072] The (C) acrylic resin has high toughness while achieving a good balance between flexibility and strength. A preferable acrylic resin is a crosslinkable functional group-containing (meth)acrylic copolymer obtained by polymerizing a monomer having an epoxy group, a glycidyl group, an alcoholic hydroxyl group, a phenolic hydroxyl group, or a carboxyl group as a crosslinkable functional group, the acrylic copolymer having a T_g (glass transition temperature) of -50°C to 50°C. Furthermore, if the acrylic resin contains acrylonitrile or the like and exhibits rubber characteristics, superior toughness is obtained.

The (C) phenoxy resin has a long molecular chain and has a structure similar to the structure of an epoxy resin. Since a phenoxy resin acts as a flexible material in a composition having a high crosslinking density and imparts high toughness, a composition having high strength and high toughness is obtained. A preferred phenoxy resin is a phenoxy resin having a main skeleton of bisphenol A type; however, in addition to that, commercially available phenoxy resins such as a bisphenol F type phenoxy resin, a bisphenol A/F mixed type phenoxy resin,

and a brominated phenoxy resin are also preferable.

[0073] Regarding the (D) surface-treated inorganic filler, an inorganic filler that has been surface-treated with a coupling agent may be used. As the inorganic filler material, the above-mentioned known inorganic fillers can be used; however, preferred examples include silica and alumina. When the inorganic filler is surface-treated with a coupling agent, the inorganic filler acquires satisfactory dispersibility. Accordingly, excellent fluidity is obtained, and therefore, the adhesive force to the metal layer can be increased. Also, since the inorganic filler can be filled at a high density, the water absorption ratio can be lowered, and the moisture resistance can be increased.

[0074] For example, the surface treatment of an inorganic filler material with a silane coupling agent is carried out according to a known method, by dispersing the inorganic filler material in a silane coupling agent solution, thereby causing the hydroxyl groups present at the surface of the inorganic filler to react with silanol groups produced as a result of hydrolysis of hydrolyzable groups such as alkoxy groups of the silane coupling agent, and producing Si-O-Si bonds on the surface of the inorganic filler.

[0075] The thickness of the adhesive layer 15 is not particularly limited; however, usually, from the viewpoint of handleability, the thickness is preferably 3 μm or more, more

preferably 5 μm or more, and from the viewpoint of contributing to thickness reduction of the semiconductor package, the thickness is preferably 100 μm or less, and more preferably 50 μm or less. The adhesive layer 15 may be composed of a single layer, or may be composed of multiple layers.

[0076] The adhesive layer 15 is such that the storage modulus at 25°C as measured after heating the adhesive layer for 3 hours at 100°C is 10 GPa or less. The storage modulus is a value obtainable after heating the adhesive layer for 3 hours at 100°C, sufficiently cooling the adhesive layer, subsequently initiating measurement using a dynamic viscoelasticity analyzer from 0°C at a rate of temperature increase of 5°C/min at a frequency of 1 Hz, and making measurement at the time point at which the temperature reached 25°C.

[0077] If the storage modulus at 25°C obtainable after the adhesive layer has been heated for 3 hours at 100°C is 10 GPa or less, when the adhesive layer 15 is preliminarily cured as a laminate of the metal layer 14, the adhesive layer 15, and the semiconductor chip C, the warpage occurring in the laminate as a result of the difference between the coefficient of linear expansion of the semiconductor chip C and the coefficient of linear expansion of the metal layer 14 due to the heat of preliminary curing, is not retained as received, even after cooling. Therefore, the occurrence of warpage in the laminate

after preliminary curing can be suppressed. Furthermore, if the adhesive layer is cured until the storage modulus at 25°C obtainable after the adhesive layer has been heated for 3 hours at 100°C reaches 10 GPa or less, the generation of voids occurring when flip chip connection is performed can be suppressed.

[0078] The storage modulus can be adjusted using the molecular weight of the polymer or the like, and generally, as the molecular weight is lower, the storage modulus becomes lower. It is also possible to adjust the storage modulus by incorporating a plasticizer, a filler, or the like. Furthermore, in a (meth)acrylic copolymer, the storage modulus can be widely adjusted by means of a crosslinking agent.

[0079] The adhesive layer 15 has a curing rate of 10% to 100% when the adhesive layer is heated for 3 hours at 100°C. When the curing rate of the adhesive layer 15 obtainable when the adhesive layer has been heated for 3 hours at 100°C is 10% to 100%, the generation of voids occurring in the adhesive layer 15 at the time of flip chip connection can be suppressed. The curing rate can be determined as follows using a differential scanning calorimeter (DSC). First, the total calorific value (H_0) is measured from a sample before curing of the adhesive layer 15 using a differential scanning calorimeter (DSC), and the residual calorific value (H_t) is measured from a cured product sample obtained after heating for 3 hours at 100°C.

Then, the curing rate is calculated by the following Formula (4):

$$\text{Curing rate (\%)} = (H_0 - H_t) / H_0 \times 100 \quad (4)$$

H₀: Total calorific value

H_t: Residual calorific value

[0080] Furthermore, the adhesive layer 15 is preferably such that the peeling force (23°C, peeling angle 180°, linear velocity 300 mm/min) between the adhesive layer 15 and the metal layer 14 in the B-stage (uncured state or semicured state) is 0.3 N or greater. If the peeling force is less than 0.3 N, detachment occurs between the semiconductor wafer W or the semiconductor chip C and the adhesive layer 15, or between the adhesive layer 15 and the metal layer 14, at the time of dicing of the semiconductor wafer W, and there is a risk that chipping (defects) may occur in the semiconductor chip C.

[0081] It is preferable that the water absorption ratio of the adhesive layer 15 is 1.5 vol% or less. The method for measuring the water absorption ratio is as follows. That is, an adhesive layer 15 (film-like adhesive) having a size of 50 × 50 mm is used as a sample, and the sample is dried for 3 hours at 120°C in a vacuum dryer and is left to cool naturally in a desiccator. Subsequently, the dry mass is measured and is designated as M₁. The sample is immersed in distilled water for 24 hours at room temperature, and after the sample is taken out, the sample surface is wiped with a filter paper. The sample

is immediately weighed, and the weight is designated as M2. The water absorption ratio is calculated by the following Formula (1).

$$\text{Water absorption ratio (vol\%)} = [(M2 - M1) / (M1/d)] \times 100 \quad (1)$$

wherein d represents the density of the film.

If the water absorption ratio is higher than 1.5 vol%, there is a risk that package cracks may occur at the time of solder reflow due to the absorbed moisture.

[0082] It is preferable that the saturation moisture absorption ratio of the adhesive layer 15 is 1.0 vol% or less. The method for measuring the saturation moisture absorption ratio is as follows. That is, a circular-shaped adhesive layer 15 (film-like adhesive) having a diameter of 100 mm is used as a sample, and the sample is dried for 3 hours at 120°C in a vacuum dryer and is left to cool naturally in a desiccator.

Subsequently, the dry mass is measured and is designated as M1. The sample is humidified for 168 hours in a constant temperature constant humidity chamber at 85°C and 85%RH, and after the sample is taken out, the sample is immediately weighed, and the weight is designated as M2. The saturation moisture absorption ratio is calculated by the following Formula (2).

$$\text{Saturation moisture absorption ratio (vol\%)} = [(M2 - M1) / (M1/d)] \times 100 \quad (2)$$

wherein d represents the density of the film.

If the saturation moisture absorption ratio is higher than 1.0 vol%, the value of vapor pressure increases as a result of moisture absorption at the time of reflow, and there is a risk that satisfactory reflow characteristics may not be obtained.

[0083] It is preferable that the residual volatile matter content of the adhesive layer 15 is 3.0 wt% or less. The method for measuring the residual volatile matter content is as follows. That is, an adhesive layer 15 (film-like adhesive) having a size of 50 × 50 mm is used as a sample, and the initial mass of the sample is measured and designated as M1. The sample is heated for 2 hours at 200°C in a hot air circulation constant temperature chamber, subsequently the sample is weighed, and the weight is designated as M2. The residual volatile matter content is calculated by the following Formula (3).

$$\begin{aligned} \text{Residual volatile matter content (wt\%)} &= [(M2 - M1)/M1] \\ &\times 100 \end{aligned} \quad (3)$$

If the residual volatile matter content is higher than 3.0 wt%, the solvent is volatilized by the heating during packaging, and there is a risk that voids may occur in the interior of the adhesive layer 15, and package cracks may occur.

[0084] It is preferable that the ratio of the coefficient of linear expansion of the metal layer 14 with respect to the coefficient of linear expansion of the adhesive layer 15 (linear expansion coefficient of metal layer 14/linear expansion

coefficient of adhesive layer 15) is 0.2 or higher. If this ratio is less than 0.2, detachment between the metal layer 14 and the adhesive layer 15 is likely to occur, and there is a risk that package cracks may occur at the time of packaging, and reliability may be lowered.

[0085] (Separator)

A separator is intended to improve handleability of the adhesive layer 15 as well as to protect the adhesive layer 15. As the separator, polyester (PET, PBT, PEN, PBN, PTT)-based films, polyolefin (PP, PE)-based films, copolymer (EVA, EEA, EBA)-based films, and films having their adhesiveness or mechanical strength further enhanced by substituting portions of these materials, can be used. Laminates of these films may also be used.

[0086] The thickness of the separator is not particularly limited, and may be appropriately set; however, the thickness is preferably 25 to 50 μm .

[0087] (Tape for electronic device packaging 10)

The method for producing the tape for electronic device packaging 10 according to the present embodiment will be explained. First, the adhesive layer 15 can be formed by utilizing a conventional method of preparing a resin composition and forming a film-like layer. Specifically, for example, a method of forming the adhesive layer 15 by applying the resin composition on an appropriate separator (release

paper or the like), and drying the resin composition (in a case in which thermal curing is needed, the resin composition is subjected to a heating treatment as necessary and dried), may be used. The resin composition may be a solution or a dispersion liquid. Subsequently, the adhesive layer 15 thus obtained is bonded with a metal layer 14 that has been prepared separately. Regarding the metal layer 14, a commercially available metal foil may be used. Thereafter, the adhesive layer 15 and the metal layer 14 are precut into a circular label shape having a predetermined size using a press-cutting blade, and unnecessary parts of the periphery are removed.

[0088] Next, a pressure-sensitive adhesive tape 13 is produced. The base film 11 can be formed by a conventionally known film-forming method. Examples of the film-forming method include a calender film-forming method, a method of casting in an organic solvent, an inflation extrusion method in a sealed system, a T-die extrusion method, a co-extrusion method, and a dry lamination method. Next, a pressure-sensitive adhesive layer composition is applied on the base film 11 and dried (by heating and crosslinking as necessary), and thus a pressure-sensitive adhesive layer 12 is formed. Examples of the application method include roll coating, screen coating, and gravure coating. The pressure-sensitive adhesive layer 12 may be formed on the base film 11 by applying the pressure-sensitive adhesive layer

composition directly on the base film 11. Alternately, after the pressure-sensitive adhesive layer 12 is formed by applying the pressure-sensitive adhesive layer composition on release paper that has been release-treated on the surface or the like, the pressure-sensitive adhesive layer 12 may be transferred onto the base film 11. Thereby, a pressure-sensitive adhesive tape 13 having the pressure-sensitive adhesive layer 12 formed on the base film 11 is produced.

[0089] Subsequently, the pressure-sensitive adhesive tape 13 is laminated on the circular-shaped separator provided with the metal layer 14 and the adhesive layer 15 such that the metal layer 14 and the pressure-sensitive adhesive layer 12 are brought into contact. If necessary, the pressure-sensitive adhesive tape 13 is also precut into a circular label shape having a predetermined size, and thereby the tape for electronic device packaging 10 is produced.

[0090] <Method for use>

Next, the method for producing a semiconductor device using the tape for electronic device packaging 10 of the present embodiment will be explained with reference to Fig. 2.

[0091] The method for producing a semiconductor device includes at least a step of sticking a semiconductor wafer W on a pressure-sensitive adhesive tape-integrated type tape for electronic device packaging 10 (mounting step); a step of dicing the semiconductor wafer W and forming semiconductor chips C

(dicing step); a step of detaching the laminates of a metal layer 14, an adhesive layer 15 and a semiconductor chip C from the pressure-sensitive adhesive layer 12 of the pressure-sensitive adhesive tape 13 (pick-up step); a step of preliminarily curing the laminates thus obtained (preliminary curing step); and a step of flip-chip connecting the semiconductor chips C onto an adherend 16 (flip-chip connection step).

[0092] [Mounting step]

First, a separator that is optionally provided on a pressure-sensitive adhesive tape-integrated type tape for electronic device packaging 10 is appropriately detached, and as illustrated in Fig. 2(A), a semiconductor wafer W is stuck on an adhesive layer 15, and this is fixed by adhering and holding the wafer (mounting step). At this time, the adhesive layer 15 is in an uncured state (including a semicured state). Also, the pressure-sensitive adhesive tape-integrated type tape for electronic device packaging 10 is stuck on the back surface of the semiconductor wafer W. The back surface of the semiconductor wafer W means the surface on the opposite side of the circuit surface (also called a non-circuit surface, a non-electrode-formed surface, or the like). The method for sticking is not particularly limited; however, a method based on pressure bonding is preferred. Pressure bonding is usually carried out by pressing with a pressing means such as a pressing roll.

[0093] [Dicing step]

Next, as illustrated in Fig. 2(B), dicing of the semiconductor wafer W is performed. Thereby, the semiconductor wafer W is individually divided (subdivided) by cutting the wafer into a predetermined size, and thus semiconductor chips C are produced. Dicing is carried out according to a conventional method, for example, from the circuit surface side of the semiconductor wafer W. In the present step, for example, a cutting method called full-cut, by which incisions are inserted to reach the tape for electronic device packaging 10, can be employed. The dicing apparatus that is used for the present step is not particularly limited, and any conventionally known apparatus can be used. Furthermore, since the semiconductor wafer W is adhered and fixed by the tape for electronic device packaging 10 with excellent adhesiveness, chip cracking or chip flying can be suppressed, and damage of the semiconductor wafer W can also be suppressed. In the case of implementing expansion of the pressure-sensitive adhesive tape-integrated type tape for electronic device packaging 10, the expansion can be carried out using a conventionally known expanding apparatus.

[0094] [Pick-up step]

As illustrated in Fig. 2(C), picking up of the semiconductor chips C is performed, and thereby the semiconductor chips C are detached from the pressure-sensitive

adhesive tape 13 together with the adhesive layer 15 and the metal layer 14. The method for picking up is not particularly limited, and various conventionally known methods can be employed. For example, a method of pushing up the individual semiconductor chips C using needles from the base film 11 side of the tape for electronic device packaging 10, and picking up the pushed semiconductor chips C using a pick-up apparatus, may be used.

[0095] [Preliminary curing step]

In order to prevent bumping in the adhesive layer 15 in the subsequent flip-chip connection step, preliminary curing by which the adhesive layer 15 in the laminate of the metal layer 14, the adhesive layer 15 and the semiconductor chip C is cured in advance, is performed. The conditions for the preliminary curing may be set as appropriate to the extent that bumping of the adhesive layer 15 does not occur; however, it is preferable to heat the adhesive layer 15 for about 4 hours to 15 minutes at 100°C to 150°C.

[0096] [Flip-chip connection step]

The semiconductor chips C thus picked up are fixed, as illustrated in Fig. 2(D), to an adherend 16 such as a substrate by a flip-chip bonding method (flip-chip packaging method). Specifically, the semiconductor chips C are fixed to the adherend 16 by a conventional method, in a state in which the circuit surface (also called a surface, a circuit

pattern-formed surface, an electrode-formed surface, or the like) of a semiconductor chip C faces the adherend 16. For example, first, a flux is attached to the bumps 17 as connection parts that are formed on the circuit surface side of the semiconductor chips C. Next, the bumps 17 of the semiconductor chips C are contacted with a conductor material 18 (solder or the like) for bonding, which is adhered to a connection pad of the adherend 16, and then the bumps 17 and the conductor material 18 are melted while being pressed. Thereby, electrical conduction between the semiconductor chips C and the adherend 16 is secured, and the semiconductor chips C can be fixed to the adherend 16 (flip-chip bonding process). At this time, gap is formed between the semiconductor chips C and the adherend 16, and the distance of gap is generally about 30 μm to 300 μm . Furthermore, after the semiconductor chips C are flip-chip bonded (flip-chip connection) onto the adherend 16, the flux remaining on the facing surfaces of the semiconductor chips C and the adherend 16 or in the gaps therebetween is washed and removed, a sealant material (sealant resin or the like) is filled in the gap to encapsulate the system.

[0097] As the adherend 16, various substrates such as a lead frame and a circuit board (wiring circuit board or the like) can be used. The material for such a substrate is not particularly limited; however, a ceramic substrate or a plastic substrate may be used. Examples of the plastic substrate

include an epoxy substrate, a bismaleimide triazine substrate and a polyimide substrate. Also, a chip-on-chip structure can be obtained by using another semiconductor chip as the adherend 16, and flip-chip connecting the semiconductor chip C thereon.

[0098] <Examples>

Next, Examples and Comparative Examples will be explained in detail in order to further clarify the effects of the invention; however, the invention is not intended to be limited to these Examples.

[0099] (1) Production of pressure-sensitive adhesive tape

As a base film, the following was produced.

(Base film a-1)

Resin beads of a zinc ionomer a of an ethylene-methacrylic acid-ethyl methacrylate (mass ratio 8:1:1) ternary copolymer (density: 0.96 g/cm³, zinc ion content: 4% by mass, chlorine content: less than 1% by mass, Vicat softening point: 56°C, melting point: 86°C), which had been synthesized by a radical polymerization method, were melted at 140°C. The molten resin beads were molded into a long film form having a thickness of 100 μ m using an extruder, and thus a base film a-1 was produced.

[0100] (Pressure-sensitive adhesive layer composition b-1)

As an acrylic copolymer (A1) having functional groups, a copolymer that was composed of 2-ethylhexyl acrylate, 2-hydroxyethyl acrylate and methacrylic acid and had a mass

average molecular weight of 750,000, with a proportion of 2-ethylhexyl acrylate of 55 mol%, was produced. Next, 2-isocyanatoethyl methacrylate was added thereto so as to obtain an iodine value of 25, and thus an acrylic copolymer (a1) having a glass transition temperature of -50°C, a hydroxyl group value of 10 g KOH/g, and an acid value of 5 mg KOH/g was produced.

A mixture obtained by adding 3 parts by mass of CORONATE L (manufactured by Tosoh Corporation, trade name) as polyisocyanate to 100 parts by mass of the acrylic copolymer (a1), and adding thereto 3 parts by mass of ESACURE KIP 150 (manufactured by Lamberti S.p.A., trade name) as a photopolymerization initiator, was dissolved in ethyl acetate and stirred. Thus, a pressure-sensitive adhesive layer composition b-1 was obtained.

[0101] <Pressure-sensitive adhesive tape (1)>

The pressure-sensitive adhesive layer composition b-1 thus prepared was applied on a releasable liner formed from a release-treated polyethylene terephthalate film, so as to obtain a thickness after drying of 10 μm , and the composition was dried for 3 minutes at 110°C. Subsequently, the release liner was bonded with the base film a-1 described above. Thus, a pressure-sensitive adhesive tape (1) having a pressure-sensitive adhesive layer formed on the base film was produced.

[0102] (2) Production of adhesive layer

(Adhesive layer composition c-1)

10 parts by mass of acrylonitrile-butadiene rubber (acrylonitrile content 40% by mass), 17 parts by mass of a novolac type epoxy resin (manufactured by DIC Corp., trade name "N-775", epoxy equivalent 195, softening point 78°C), 40 parts by mass of a liquid bisphenol A type epoxy resin (manufactured by Nippon Steel & Sumikin Chemical Co., Ltd., trade name "YD-128", Mw 400, epoxy equivalent 190), and 32 parts by mass of a phenolic resin (manufactured by Meiwa Plastic Industries, Ltd., trade name "H-4") as a curing agent were dissolved in methyl ethyl ketone, and thus an adhesive layer composition solution was prepared.

[0103] (Adhesive layer composition c-2)

80 parts by mass of an acrylic resin (Nagase Chemtex Corp., trade name "TEISANRESIN SG-P3", Mw 850,000, Tg 12°C), 10 parts by mass of a naphthalene type epoxy resin (manufactured by DIC Corp., trade name "HP-4700"), and 10 parts by mass of a phenolic resin (manufactured by Meiwa Plastic Industries, Ltd., trade name MEH7851") as a curing agent were dissolved in methyl ethyl ketone, and thus an adhesive layer composition solution was prepared.

[0104] (Adhesive layer composition c-3)

100 parts by mass of an acrylic resin (manufactured by Nagase Chemtex Corp., "TEISANRESIN SG-70L", Tg -13°C), 353 parts by mass of a cresol novolac type epoxy resin (manufactured by

Nippon Kayaku Co., Ltd., trade name "EOCN-1020", epoxy equivalent 198, softening point 64°C), 46 parts by mass of a liquid bisphenol A type epoxy resin (manufactured by Nippon Steel & Sumikin Chemical Co., Ltd., trade name "YD-128", Mw 400, epoxy equivalent 190), 3 parts by mass of imidazole (manufactured by Shikoku Chemicals Corp., trade name "2PHZ-PW") as a curing agent, and 330 parts by mass of a silica filler (manufactured by Admatechs Co., Ltd., trade name "SO-C2", average particle size 0.5 μm) were dissolved or dispersed in methyl ethyl ketone, and thus an adhesive layer composition solution was prepared.

[0105] (Adhesive layer composition c-4)

100 parts by mass of a bisphenol A type phenoxy resin (manufactured by Nippon Steel & Sumikin Chemical Co., Ltd., trade name "YP-50S", Mw 60,000, Tg 84°C), 40 parts by mass of a cresol novolac type epoxy resin (manufactured by Nippon Kayaku Co., Ltd., trade name "EOCN-1020", epoxy equivalent 198, softening point 64°C), 100 parts by mass of a liquid bisphenol A type epoxy resin (manufactured by Nippon Steel & Sumikin Chemical Co., Ltd., trade name "YD-128", Mw 400, epoxy equivalent 190), 1.5 parts by mass of imidazole (manufactured by Shikoku Chemicals Corp., trade name "2PHZ-PW") as a curing agent, and 200 parts by mass of a silica filler (manufactured by Admatechs Co., Ltd., trade name "SO-C2", average particle size 0.5 μm) were dissolved or dispersed in methyl ethyl ketone,

and thus an adhesive layer composition solution was prepared.

[0106] (Adhesive layer composition c-5)

10 parts by mass of acrylonitrile-butadiene rubber (acrylonitrile content 40% by mass), 17 parts by mass of a novolac type epoxy resin (manufactured by DIC Corp., trade name "N-775", epoxy equivalent 195, softening point 78°C), 40 parts by mass of a liquid bisphenol A type epoxy resin (manufactured by Nippon Steel & Sumikin Chemical Co., Ltd., trade name "YD-128", Mw 400, epoxy equivalent 190), and 25 parts by mass of a phenolic resin (manufactured by Meiwa Plastic Industries, Ltd., trade name "H-4") as a curing agent were dissolved in methyl ethyl ketone, and thus an adhesive layer composition solution was prepared.

[0107] (Adhesive layer composition c-6)

100 parts by mass of a bisphenol A type phenoxy resin (manufactured by Nippon Steel & Sumikin Chemical Co., Ltd., trade name "YP-50S", Mw 60,000, Tg 84°C), 50 parts by mass of a cresol novolac type epoxy resin (manufactured by Nippon Kayaku Co., Ltd., trade name "EOCN-1020", epoxy equivalent 198, softening point 64°C), 100 parts by mass of a liquid bisphenol A type epoxy resin (manufactured by Nippon Steel & Sumikin Chemical Co., Ltd., trade name "YD-128", Mw 400, epoxy equivalent 190), 1.0 parts by mass of an imidazole (manufactured by Shikoku Chemicals Corp., trade name "2PHZ-PW") as a curing agent, and 200 parts by mass of a silica filler (manufactured

by Admatechs Co., Ltd., trade name "SO-C2", average particle size 0.5 μm) were dissolved or dispersed in methyl ethyl ketone, and thus an adhesive layer composition solution was prepared.

[0108] (Adhesive layer composition c-7)

100 parts by mass of an acrylic resin (manufactured by Nagase Chemtex Corp., trade name "TEISANRESIN SG-708-6", Tg 6°C), 280 parts by mass of a solid bisphenol A type epoxy resin (manufactured by Mitsubishi Chemical Corp., trade name "EPIKOTE 1004", softening point 97°C), 306 parts by mass of a phenolic resin (manufactured by Mitsui Chemicals, Inc., trade name "MILEX XLC-4L", melting point 62°C) as a curing agent, and 237 parts by mass of a silica filler (manufactured by Admatechs Co., Ltd., trade name "SO-C2", average particle size 0.5 μm) were dissolved or dispersed in methyl ethyl ketone, and thus an adhesive layer composition solution was prepared.

[0109] (Adhesive layer composition c-8)

100 parts by mass of an acrylic resin (manufactured by Nagase Chemtex Corp., "TEISANRESIN SG-70L", Tg -13°C), 260 parts by mass of a cresol novolac type epoxy resin (manufactured by Nippon Kayaku Co., Ltd., trade name "EOCN-1020", epoxy equivalent 198, softening point 64°C), 46 parts by mass of a liquid bisphenol A type epoxy resin (manufactured by Nippon Steel & Sumikin Chemical Co., Ltd., trade name "YD-128", Mw 400, epoxy equivalent 190), 1 part by mass of imidazole (manufactured by Shikoku Chemicals Corp., trade name "2PHZ-PW") as a curing

agent, and 330 parts by mass of a silica filler (manufactured by Admatechs Co., Ltd., trade name "SO-C2", average particle size 0.5 μm) were dissolved or dispersed in methyl ethyl ketone, and thus an adhesive layer composition solution was prepared.

[0110] <Adhesive layer (1)>

The adhesive layer composition c-1 was applied on a separator formed from a release-treated polyethylene terephthalate film, so as to obtain a thickness after drying of 5 μm , and the composition was dried for 5 minutes at 110°C. Thus, an adhesive film having an adhesive layer (1) formed on a separator was produced.

[0111] <Adhesive layer (2)>

The adhesive layer composition c-2 was applied on a separator formed from a release-treated polyethylene terephthalate film, so as to obtain a thickness after drying of 5 μm , and the composition was dried for 5 minutes at 110°C. Thus, an adhesive film having an adhesive layer (2) formed on a separator was produced.

[0112] <Adhesive layer (3)>

The adhesive layer composition c-3 was applied on a separator formed from a release-treated polyethylene terephthalate film, so as to obtain a thickness after drying of 5 μm , and the composition was dried for 5 minutes at 110°C. Thus, an adhesive film having an adhesive layer (3) formed on a separator was produced.

[0113] <Adhesive layer (4)>

The adhesive layer composition c-4 was applied on a separator formed from a release-treated polyethylene terephthalate film, so as to obtain a thickness after drying of 5 μm , and the composition was dried for 5 minutes at 110°C. Thus, an adhesive film having an adhesive layer (4) formed on a separator was produced.

[0114] <Adhesive layer (5)>

The adhesive layer composition c-5 was applied on a separator formed from a release-treated polyethylene terephthalate film, so as to obtain a thickness after drying of 5 μm , and the composition was dried for 5 minutes at 110°C. Thus, an adhesive film having an adhesive layer (5) formed on a separator was produced.

[0115] <Adhesive layer (6)>

The adhesive layer composition c-6 was applied on a separator formed from a release-treated polyethylene terephthalate film, so as to obtain a thickness after drying of 5 μm , and the composition was dried for 5 minutes at 110°C. Thus, an adhesive film having an adhesive layer (6) formed on a separator was produced.

[0116] <Adhesive layer (7)>

The adhesive layer composition c-7 was applied on a separator formed from a release-treated polyethylene terephthalate film, so as to obtain a thickness after drying

of 5 μm , and the composition was dried for 5 minutes at 110°C. Thus, an adhesive film having an adhesive layer (7) formed on a separator was produced.

[0117] <Adhesive layer (8)>

The adhesive layer composition c-8 was applied on a separator formed from a release-treated polyethylene terephthalate film, so as to obtain a thickness after drying of 5 μm , and the composition was dried for 5 minutes at 110°C. Thus, an adhesive film having an adhesive layer (8) formed on a separator was produced.

[0118] (3) Metal layer

The following was prepared as the metal layer.

<Metal layer (1)>

F0-WS (trade name, manufactured by Furukawa Electric Co., Ltd., copper foil, thickness 12 μm , surface roughness Rz 1.3 μm)

[0119] (4) Production of tape for electronic device packaging

<Example 1>

The adhesive layer (1) and the metal layer (1) obtained as described above were bonded together under the conditions of a bonding angle of 120°, a pressure of 0.2 MPa, and a velocity of 10 mm/s, and thus a single-sided adhesive film was produced. The pressure-sensitive adhesive tape (1) was precut into a shape that could be stuck to a ring frame, and the single-sided

adhesive film was precut into a shape that could cover a wafer. The pressure-sensitive adhesive layer of the pressure-sensitive adhesive tape (1) and the metal layer side of the single-sided adhesive film were bonded together such that the pressure-sensitive adhesive layer at the periphery of the single-sided adhesive film would be exposed. Thus, a tape for electronic device packaging of Example 1 was produced.

[0120] <Examples 2 to 4 and Comparative Examples 1 to 4>

Tapes for electronic device packaging of Examples 2 to 4 and Comparative Examples 1 to 4 were produced by a technique similar to that of Example 1, except that the combinations of the pressure-sensitive adhesive tape, the adhesive layer composition, and the metal layer as described in Table 1 were employed.

[0121] The tapes for electronic device packaging according to Examples 1 to 4 and Comparative Examples 1 to 4 were subjected to the following measurement and evaluations. The results are presented in Table 1.

[0122] (Storage modulus)

The storage moduli at 25°C of the adhesive layers used in the various Examples and various Comparative Examples were measured as follows. The adhesive layer composition related to the adhesive layer used in each of the Examples and Comparative Examples was applied on a separator of polyethylene terephthalate (PET) having a thickness of 25 μm , so as to obtain

a film thickness after drying of 30 μm , and the composition was dried. Subsequently, the adhesive layer was stuck onto a separator of polyethylene terephthalate (PET) having a thickness of 25 μm , this adhesive layer was peeled off from the separator, and the adhesive layers were bonded together. Thus, a specimen having a thickness of 1 mm, a width of 5 mm, and a length of 25 mm was prepared. The specimen thus obtained was heated for 3 hour at 100°C, and then measurement was initiated using a dynamic viscoelasticity analyzer (manufactured by UBM K.K., trade name: RHEOGEL-E4000) from 0°C at a rate of temperature increase of 5°C/min and at a frequency of 1 Hz, with the distance between chucks being set to 15 mm. The value obtained at the time point at which the temperature reached 25°C was designated as the storage modulus. The measurement results are presented in Table 1.

[0123] (Curing rate)

The curing rate was determined as follows, using a differential scanning calorimeter (DSC). First, the total calorific value (H_0) was measured from a sample before curing of the adhesive layer 15, and the residual calorific value (H_t) was measured from a cured product sample obtained by heating the adhesive layer for 3 hours at 100°C, using a differential scanning calorimeter (DSC). Then, the curing rate was calculated by the following Formula (4). The results are presented in Table 1.

$$\text{Curing rate (\%)} = (H_0 - H_t) / H_0 \times 100 \quad (4)$$

[0124] (Evaluation of warpage)

The adhesive layer of each of the tapes for electronic device packaging according to the various Examples and Comparative Examples was adhered to the back surface of a bump-attached silicon wafer (bump: copper pillars and solder, bump height: about 40 μm) having a thickness of 200 μm , and dicing was performed. Thus, the silicon wafer was divided into chips for evaluation each having a size of 7.5 mm $\times$ 7.5 mm. The pressure-sensitive adhesive layer was irradiated with ultraviolet radiation at a dose of 200 mJ/cm² through the base film side of the pressure-sensitive adhesive tape, using an air-cooled high pressure mercury lamp (80 W/cm, distance of radiation: 10 cm), and then preliminary curing of the adhesive layer was performed by heating the laminate of the metal layer, the adhesive layer and the silicon chip for 3 hours at 100°C. For ten laminates that had been sufficiently cooled, each laminate was placed on a flat stand, one edge was pressed, and the warped-up height was measured with calipers. The average value was designated as the amount of warpage. A sample with an amount of warpage of less than 1 mm was rated as O as a good product; a sample having an amount of warpage of 1 mm or more and less than 3 mm was rated as Δ as an acceptable product; and a sample having an amount of warpage of 3 mm or more was rated as X as a defective product. The results are presented

in Table 1.

[0125] (Evaluation of voids)

A glass epoxy substrate (glass epoxy base material: thickness 420 μm , copper wiring: thickness 9 μm , pitch of 80 μm) was prepared, and for those laminates having an amount of warpage of less than 3 mm, the bumps of the semiconductor chip were mounted on the glass epoxy substrate (mounting conditions: pressure bonding head temperature: 260°C/for 10 seconds/1 MPa) using a flip chip bonder (Sinkawa, Ltd., trade name "LFB-2301"). Thus, a semiconductor device for evaluation was obtained.

[0126] An image of the external appearance was captured using an ultrasonic image diagnostic apparatus (Hitachi Power Solutions Co., Ltd., trade name "FS300III"). The image of the external appearance was analyzed using an image processing software program, Adobe Photoshop (registered trademark), void parts of the adhesive layer were identified by color tone correction and black and white conversion, and the proportion occupied by the void parts was calculated by histogram. The area of the adhesive layer on the chip was designated as 100%, and the proportion occupied by the void parts was evaluated by the following criteria.

The proportion occupied by the void parts is 10% or less:

◎ as an excellent product

The proportion occupied by the void parts is more than 10% and 20% or less: ○ as a good product

The proportion occupied by the void parts is more than
20%: × as a defective product

[0127] [Table 1]

	Pressure-sensitive adhesive tape	Adhesive layer	Curing rate (%)	Metal layer	Storage modulus (Gpa)	Evaluation of warpage	Evaluation of voids
Example 1	(1)	(1)	10	(1)	0.3	O	O
Example 2	(1)	(2)	50	(1)	1	O	⊙
Example 3	(1)	(3)	100	(1)	8	O	⊙
Example 4	(1)	(4)	100	(1)	10	△	⊙
Comparative Example 1	(1)	(5)	9	(1)	0.1	O	×
Comparative Example 2	(1)	(6)	100	(1)	11	×	⊙
Comparative Example 3	(1)	(7)	10	(1)	11	×	O
Comparative Example 4	(1)	(8)	9	(1)	2	⊙	×

[0128] As shown in Table 1, the tapes for electronic device packaging according to Examples 1 to 4 were such that the storage modulus of the adhesive layer obtained after heating the tape for 3 hours at 100°C was 10 GPa or less, and the curing rate of the adhesive layer obtainable when the tape was heated for 3 hours at 100°C was 10% to 100%. Therefore, satisfactory results were obtained for the evaluation of warpage and the evaluation of voids.

[0129] In contrast, the tapes for electronic device packaging according to Comparative Example 1 and Comparative Example 4 were such that since the curing rate of the adhesive layer obtainable when the tape was heated for 3 hours at 100°C was less than 10%, inferior results were obtained for the evaluation of voids. Furthermore, the tapes for electronic device packaging according to Comparative Example 2 and Comparative Example 3 were such that since the storage modulus of the adhesive layer obtained after heating the tape for 3 hours at 100°C was larger than 10 GPa, inferior results were obtained for the evaluation of warpage.

EXPLANATIONS OF LETTERS OR NUMERALS

- [0130] 10: Tape for electronic device packaging
- 11: Base film
 - 12: Pressure-sensitive adhesive layer
 - 13: Pressure-sensitive adhesive tape
 - 14: Metal layer
 - 15: Adhesive layer

CLAIMS

1. A tape for electronic device packaging, comprising:
 - a pressure-sensitive adhesive tape having a base film and a pressure-sensitive adhesive layer;
 - a metal layer provided by lamination on a surface of the pressure-sensitive adhesive layer, the surface being on the opposite side of the base film; and
 - an adhesive layer provided on a surface of the metal layer, the surface being on the opposite side of the pressure-sensitive adhesive layer, and intended for adhering the metal layer to the back surface of an electronic device,wherein the adhesive layer has a storage modulus of 10 GPa or less after being heated for 3 hours at 100°C, and has a curing rate of 10% to 100% when heated for 3 hours at 100°C.
2. The tape for electronic device packaging according to claim 1, wherein the metal layer includes copper or aluminum.
3. The tape for electronic device packaging according to claim 1 or 2, wherein the adhesive layer contains: (A) an epoxy resin, (B) a curing agent, (C) an acrylic resin or a phenoxy resin, and (D) a surface-treated inorganic filler.
4. The tape for electronic device packaging according to any one of claims 1 to 3, wherein the pressure-sensitive adhesive layer contains an acrylic polymer configured to include an acrylic acid ester represented by the formula: $\text{CH}_2=\text{CHCOOR}$ (wherein R represents an alkyl group having 4 to 18 carbon atoms),

a hydroxyl group-containing monomer, and an isocyanate compound having a radical reactive carbon-carbon double bond in the molecule.