

DESCRIPTION

Title of Invention

EVALUATION METHOD FOR LIGHT-CURING ADHESIVE,
INTEGRATED DICING AND DIE-BONDING FILM AND
5 MANUFACTURING METHOD FOR SAME, AND
MANUFACTURING METHOD FOR SEMICONDUCTOR DEVICE

Technical Field

[0001] The present invention relates to a method for evaluating a
photocurable adhesive, a dicing/die bonding integrated film and a
10 manufacturing method therefor, and a method for manufacturing a
semiconductor device.

Background Art

[0002] In the manufacturing of semiconductor chips, a dicing step of
individualizing a semiconductor wafer into individual semiconductor
15 chips and a die bonding step of bonding the individualized semiconductor
chips to a lead frame, a package substrate, or the like are generally
included. In such manufacturing of semiconductor chips, a dicing/die
bonding integrated film, which is obtained by combining a dicing film
including a photocurable adhesive layer composed of a photocurable
20 adhesive to be used in fixing of the semiconductor wafer in the dicing
step and a die bonding film including a bonding adhesive layer to be used
in bonding of the semiconductor chips to a lead frame, a package
substrate, or the like, is mainly used.

[0003] In recent years, as an example of a method for manufacturing a
25 semiconductor chip by individualizing a thin semiconductor wafer, a
method of making trenches which will be folding lines in a

semiconductor wafer without the semiconductor wafer being completely cut and a method of forming a modified layer by irradiating the inside of a semiconductor wafer along lines intended to be cut with laser light without the semiconductor wafer being completely cut have been proposed. The former is called half cut dicing, and the latter is called stealth dicing (for example, Patent Literatures 1 and 2). In these methods, in the case of using a thin semiconductor wafer, chip floating in which parts between a photocurable adhesive layer and a bonding adhesive layer are peeled apart by influence of warpage of the semiconductor wafer occurs in some cases. When chip floating occurs, an adhesive force at a part peeled off in the subsequent ultraviolet irradiation step is hardly decreased by oxygen inhibition, and there is a concern that this affects pickup property in the pickup step. In order to suppress chip floating, it is necessary to improve the adhesive force of the photocurable adhesive layer; however, when the adhesive force is improved too much, peeling strength after ultraviolet irradiation is increased, and this affects pickup property in some cases. Therefore, in the case of using the dicing/die bonding integrated film in the manufacturing of thin semiconductor chips, a dicing/die bonding integrated film that can improve pickup property while suppressing chip floating is required, and selection of a photocurable adhesive constituting a photocurable adhesive layer of the dicing/die bonding integrated film becomes important.

Citation List

Patent Literature

[0004] Patent Literature 1: Japanese Unexamined Patent Publication No.

2002-192370

Patent Literature 2: Japanese Unexamined Patent Publication No.
2003-338467

Summary of Invention

5 Technical Problem

[0005] However, in the manufacturing of semiconductor chips, it is difficult to preliminarily predict whether a photocurable adhesive, which will be used as a photocurable adhesive layer of a dicing/die bonding integrated film, can improve pickup property while suppressing chip floating, and this is not known in many cases unless the photocurable adhesive is actually used.

10 [0006] The present invention is conceived in view of such circumstances, and a main object of the present invention is to provide a novel method for evaluating a photocurable adhesive to be used in a dicing/die bonding integrated film.

15 Solution to Problem

[0007] As an influencing factor of adhesion between an adherend and an adhesive, the adhesive force of the adhesive (bulk property of the adhesive), an interaction in an interface between the adherend and the adhesive (surface property of the adhesive), and the like are mentioned. Generally, it has been known that the bulk property contributes greatly to the adhesion than the surface property, and there is a tendency the adhesion is controlled by adjusting the bulk property. However, in chip floating of the thin semiconductor chip, the influence of the surface property is also not negligible, and for example, a stringing phenomenon that the adhesive is stretched like strings without being broken when the

adhesive is peeled off from the adherend is also considered to have great influence. The present inventors have speculated a peeling mechanism of an adhesive from a laminate composed of an adherend and the adhesive as follows. First, when the adhesive is pulled from the laminate composed of the adherend and the adhesive, stringiness from the adhesive occurs, and the stringiness is peeled off from the adherend interface when a stress reaches a stress necessary for peeling while the adherend is deformed. Then, the peeled stringiness contracts, contraction stress of the stringiness is stress-concentrated to other stringiness, this is repeated, and thereby, finally, the adherend and the adhesive are peeled apart. In such a peeling mechanism, when the adhesive is pulled at a constant stress, an effect (contraction effect) that, as stress concentration due to stringiness is greater, a stress necessary for peeling in other stringiness is decreased occurs, and thus peeling between the adherend and the adhesive is likely to occur. The present inventors have found that the proportion of such a contraction effect can be estimated by measuring tension and compression behavior in a tensile test and have completed the present invention.

[0008] An aspect of the present invention provides a method for evaluating a photocurable adhesive to be used in a dicing/die bonding integrated film. This method for evaluating a photocurable adhesive includes: a first step in which a photocurable adhesive sheet composed of a photocurable adhesive is prepared, a tensile test is performed with respect to the photocurable adhesive sheet under the following tensile and compression conditions to create a graph of a test force with respect to displacement, and an area surrounded by a hysteresis curve thus obtained

is obtained as loss work from the hysteresis curve; a second step in which a dicing/die bonding integrated film in which a base material layer, a photocurable adhesive layer composed of a photocurable adhesive, and a bonding adhesive layer are stacked in this order is prepared, the photocurable adhesive layer is irradiated with ultraviolet rays under the following irradiation conditions to form a cured product of the photocurable adhesive layer, and a peeling force when the bonding adhesive layer and the cured product of the photocurable adhesive layer are peeled apart under the following peeling conditions is measured; and a third step in which quality of the photocurable adhesive is determined on the basis of the loss work and the peeling force.

(Tensile and compression conditions)

Temperature: $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$

Humidity: $55 \pm 10\%$

Distance between chucks: 40 mm

Tensile condition: Tension at 500 mm/min until the test force becomes 0.5 N

Compression condition: Compression at 500 mm/min until the displacement becomes 0 mm

(Irradiation conditions)

Irradiation intensity: 70 mW/cm^2

Integrated quantity of light: 150 mJ/cm^2

(Peeling conditions)

Temperature: $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$

Humidity: $55 \pm 10\%$

Peeling angle: 30°

Peeling rate: 600 mm/min

[0009] Such a method for evaluating a photocurable adhesive is useful in preliminarily predicting whether a photocurable adhesive, which will be used as a photocurable adhesive layer of a dicing/die bonding integrated film, suppresses chip floating and is excellent in pickup property.

[0010] The third step may be a step in which quality of the photocurable adhesive is determined by determining whether or not the peeling force and the number of marks and the mark widths of the stringing marks satisfy the following condition (a) and the following condition (b).

Condition (a): The loss work is 1.21 N·mm or more.

Condition (b): The peeling force is 0.60 N/25 mm or less.

[0011] Another aspect of the present invention provides a method for manufacturing a dicing/die bonding integrated film, the method including a step in which a photocurable adhesive layer composed of a photocurable adhesive which is determined to be good by the aforementioned method for evaluating a photocurable adhesive is formed on a base material layer, and a step in which a bonding adhesive layer is formed on the photocurable adhesive layer.

[0012] Still another aspect of the present invention provides a method for manufacturing a semiconductor device, the method including a step in which the bonding adhesive layer of the dicing/die bonding integrated film obtained by the aforementioned manufacturing method is pasted to a semiconductor wafer, a step in which at least the semiconductor wafer and the bonding adhesive layer are individualized by dicing, a step in which the photocurable adhesive layer is irradiated with ultraviolet rays to form a cured product of the photocurable adhesive layer, a step in

which a semiconductor element attached with the bonding adhesive layer is picked up from the cured product of the photocurable adhesive layer, and a step in which the semiconductor element is bonded to a support substrate for mounting a semiconductor element via the bonding adhesive layer.

[0013] A thickness of the semiconductor wafer may be 35 μm or less. Stealth dicing may be applied as the dicing.

[0014] Still another aspect of the present invention provides a dicing/die bonding integrated film including a base material layer, a photocurable adhesive layer composed of a photocurable adhesive which is determined to be good by the aforementioned method for evaluating a photocurable adhesive, and a bonding adhesive layer in this order.

Advantageous Effects of Invention

[0015] According to the present invention, there is provided a novel method for evaluating a photocurable adhesive to be used in a dicing/die bonding integrated film. Furthermore, according to the present invention, there are provided a dicing/die bonding integrated film and a manufacturing method therefor based on such a method for evaluating a photocurable adhesive. Further, according to the present invention, there is provided a method for manufacturing a semiconductor device using such a dicing/die bonding integrated film.

Brief Description of Drawings

[0016] FIG. 1 is a schematic cross-sectional view illustrating an embodiment of a dicing/die bonding integrated film.

FIG. 2 is a schematic cross-sectional view for describing an embodiment of a method for manufacturing a semiconductor device, in

which FIGS. 2(a), 2(b), 2(c), 2(d), and 2(e) are schematic cross-sectional views illustrating respective steps.

FIG. 3 is a schematic cross-sectional view for describing an embodiment of the method for manufacturing a semiconductor device, in which FIGS. 3(f), 3(g), 3(h), and 3(i) are schematic cross-sectional views illustrating respective steps.

FIG. 4 is a schematic cross-sectional view illustrating an embodiment of a semiconductor device.

Description of Embodiments

[0017] Hereinafter, embodiments of the present invention will be described with reference to the drawings as appropriate. However, the present invention is not limited to the following embodiments. In the following embodiments, the constituent elements (including a step or the like) are not always indispensable unless otherwise specified. The sizes of constituent elements in the respective drawings are conceptual, and the relative size relationships between the constituent elements are not restricted to those illustrated in the respective drawings.

[0018] The same applies to numerical values and ranges thereof in the present specification, and the present invention is not limited thereby. A numerical range expressed by using "to" in the present specification indicates a range including the numerical values before and after "to" as the minimum value and the maximum value, respectively. In a numerical range described in the present specification in a stepwise manner, an upper or lower limit value described in one numerical range may be replaced with an upper or lower limit value in the other numerical range described in a stepwise manner. Furthermore, in a numerical

range described in the present specification, an upper or lower limit value of the numerical range may be replaced with a value shown in Examples.

[0019] In the present specification, (meth)acrylate means acrylate or methacrylate corresponding thereto. The same applies to other analogous expressions such as a (meth)acryloyl group and a (meth)acrylic copolymer.

[0020] In the present specification, the term "stringiness" is a deformed form of an adhesive between an adherend and the adhesive, and means that, when the adherend and the adhesive are peeled apart, the adhesive is not broken between the adhesive and the adherend to be greatly deformed like strings, depending on circumstances, like a wall.

[0021] [Method for evaluating photocurable adhesive]

A method for evaluating a photocurable adhesive to be used in a dicing/die bonding integrated film according to an embodiment includes: a first step in which a photocurable adhesive sheet composed of a photocurable adhesive is prepared, a tensile test is performed with respect to the photocurable adhesive sheet under the following tensile and compression conditions to create a graph of a test force with respect to displacement, and an area surrounded by a hysteresis curve thus obtained is obtained as loss work from the hysteresis curve; a second step in which a dicing/die bonding integrated film in which a base material layer, a photocurable adhesive layer composed of a photocurable adhesive, and a bonding adhesive layer are stacked in this order is prepared, the photocurable adhesive layer is irradiated with ultraviolet rays under the following irradiation conditions to form a cured product of the photocurable adhesive layer, and a peeling force when the cured product

of the photocurable adhesive layer is peeled off from the base material layer under the following peeling conditions is measured; and a third step in which quality of the photocurable adhesive is determined on the basis of the loss work and the peeling force.

[0022] Hereinafter, first, a dicing/die bonding integrated film including a photocurable adhesive that is an evaluation target, and a photocurable adhesive layer composed of the photocurable adhesive and a manufacturing method therefor will be described, an influencing factor of loss work that is an evaluation criterion is then discussed, and finally, each step will be described.

[0023] <Photocurable adhesive>

In the method for evaluating a photocurable adhesive according to the present embodiment, a photocurable adhesive which is cured by irradiation of ultraviolet rays may be an evaluation target. Hereinafter, as an example of the photocurable adhesive that is an evaluation target, a photocurable adhesive containing a (meth)acrylic copolymer having a reactive functional group, a photopolymerization initiator, and a cross-linking agent having two or more functional groups that can react with the reactive functional group will be described.

[0024] ((Meth)acrylic copolymer having reactive functional group)

The (meth)acrylic copolymer having a reactive functional group can be obtained, for example, by copolymerizing one or two or more types of a (meth)acrylate monomer (a1) or (meth)acrylic acid and one or two or more types of a polymerizable compound (a2) having a reactive functional group.

[0025] The (meth)acrylate monomer (a1) may be, for example, at least

one selected from the group consisting of a straight-chain or branched alkyl (meth)acrylate, an alicyclic (meth)acrylate, an aromatic (meth)acrylate, an alkoxyalkyl (meth)acrylate, an alkoxy(poly)alkylene glycol (meth)acrylate, an alkoxyalkoxyalkyl (meth)acrylate, and a
5 dialkylaminoalkyl (meth)acrylate.

[0026] Examples of the straight-chain or branched alkyl (meth)acrylate include methyl (meth)acrylate, ethyl (meth)acrylate, n-propyl (meth)acrylate, n-butyl (meth)acrylate, isobutyl (meth)acrylate, t-butyl (meth)acrylate, ethylhexyl (meth)acrylate, stearyl (meth)acrylate, lauryl
10 (meth)acrylate, and tridecyl (meth)acrylate.

[0027] Examples of the alicyclic (meth)acrylate include cyclohexyl (meth)acrylate, isobornyl (meth)acrylate, and dicyclopentanyl (meth)acrylate.

[0028] Examples of the aromatic (meth)acrylate include phenoxyethyl
15 (meth)acrylate.

[0029] Examples of the alkoxyalkyl (meth)acrylate include ethoxyethyl (meth)acrylate and butoxyethyl (meth)acrylate.

[0030] Examples of the alkoxy(poly)alkylene glycol (meth)acrylate include methoxy diethylene glycol (meth)acrylate, ethoxy diethylene glycol (meth)acrylate, butoxy triethylene glycol (meth)acrylate, and methoxy dipropylene glycol (meth)acrylate.
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[0031] Examples of the alkoxyalkoxyalkyl (meth)acrylate include 2-methoxyethoxyethyl (meth)acrylate and 2-ethoxyethoxyethyl (meth)acrylate.
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[0032] Examples of the dialkylaminoalkyl (meth)acrylate include N,N-

dimethylaminoethyl (meth)acrylate and N,N-diethylaminoethyl (meth)acrylate.

[0033] The polymerizable compound (a2) may have at least one reactive functional group selected from the group consisting of a hydroxy group and an epoxy group. The hydroxy group and the epoxy group have satisfactory reactivity with a compound (b) having an isocyanate group or the like, and thus can be suitably used. The polymerizable compound (a2) preferably has a hydroxy group.

[0034] Examples of the polymerizable compound (a2) having a hydroxy group as the reactive functional group include hydroxyalkyl (meth)acrylates such as 2-hydroxyethyl (meth)acrylate, 2-hydroxybutyl (meth)acrylate, and 2-hydroxypropyl (meth)acrylate.

[0035] Examples of the polymerizable compound (a2) having an epoxy group as the reactive functional group include (meth)acrylates having an epoxy group such as glycidyl (meth)acrylate and 3,4-epoxycyclohexyl (meth)acrylate.

[0036] The (meth)acrylic copolymer may contain (meth)acrylic acid as a monomer unit. Furthermore, the (meth)acrylic copolymer may contain other polymerizable compounds as monomer units in addition to the (meth)acrylate monomer (a1) and the polymerizable compound (a2). Examples of the other polymerizable compounds include aromatic vinyl compounds such as styrene and vinyl toluene.

[0037] The (meth)acrylic copolymer having a reactive functional group may further have a chain polymerizable functional group. That is, the (meth)acrylic copolymer having a reactive functional group may have a main chain consisting of a (meth)acrylic copolymer having a reactive

functional group and a side chain bonded to the main chain and containing a polymerizable double bond. The side chain containing a polymerizable double bond may be a (meth)acryloyl group, but is not limited thereto. The (meth)acrylic copolymer having a chain polymerizable functional group can be obtained by reacting a functional group reactive with a reactive functional group of the (meth)acrylic copolymer having a reactive functional group with one or two or more types of compounds (b) having a chain polymerizable functional group so as to introduce the chain polymerizable functional group into the side chain of the (meth)acrylic copolymer.

[0038] Examples of the functional group reactive with a reactive functional group (an epoxy group, a hydroxy group, or the like) include an isocyanate group.

[0039] Specific examples of the compound (b) having an isocyanate group include 2-methacryloxyethyl isocyanate (for example, manufactured by Showa Denko K.K., trade name "Karenc MOI").

[0040] The content of the compound (b) may be 0.3 to 1.5 mmol/g with respect to the (meth)acrylic copolymer having a reactive functional group.

[0041] The acid value of the (meth)acrylic copolymer having a reactive functional group may be, for example, 1 to 150 mg KOH/g. The hydroxyl value of the (meth)acrylic copolymer having a reactive functional group may be, for example, 1 to 150 mg KOH/g. The acid value and the hydroxyl value are measured according to JIS K0070.

[0042] The weight average molecular weight (M_w) of the (meth)acrylic copolymer having a reactive functional group may be 100000 to 1000000, 200000 to 600000, or 250000 to 400000. The weight average molecular

weight is a value in terms of polystyrene using a calibration curve of standard polystyrene by gel permeation chromatography (GPC).

[0043] (Photopolymerization initiator)

The photopolymerization initiator is not particularly limited as long as it initiates polymerization by irradiation of ultraviolet rays, and for example, a photoradical polymerization initiator and the like are exemplified. Examples of the photoradical polymerization initiator include benzoin ketal such as 2,2-dimethoxy-1,2-diphenylethan-1-one; α -hydroxy ketone such as 1-hydroxycyclohexyl phenyl ketone; α -amino ketone such as 2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)-butan-1-one; oxime ester such as 1-[4-(phenylthio)phenyl]-1,2-octadione-2-(benzoyl)oxime; phosphine oxide such as bis(2,4,6-trimethyl benzoyl)phenyl phosphine oxide; 2,4,5-triarylimidazole dimer such as 2-(o-chlorophenyl)-4,5-diphenylimidazole dimer; benzophenone compounds such as benzophenone and N,N,N',N'-tetramethyl-4,4'-diamino benzophenone; quinone compounds such as 2-ethylanthraquinone; benzoin ether such as benzoin methyl ether; benzoin compounds such as benzoin; benzyl compounds such as benzyl dimethyl ketal; acridine compounds such as 9-phenylacridine, N-phenylglycine, and coumarin. These may be used singly or in combination of two or more kinds thereof, and may be used in combination with an appropriate sensitizer.

[0044] The content of the photopolymerization initiator may be 0.1 to 20 parts by mass, 0.3 to 10 parts by mass, or 0.5 to 3 parts by mass, with respect to 100 parts by mass of the (meth)acrylic copolymer.

[0045] (Cross-linking agent)

The cross-linking agent is not particularly limited as long as it is a compound having two or more functional groups that can react with a reactive functional group (an epoxy group, a hydroxy group, or the like) of the (meth)acrylic copolymer having a reactive functional group. Examples of a bond to be formed by reaction between the cross-linking agent and the (meth)acrylic copolymer having a reactive functional group include an ester bond, an ether bond, an amide bond, an imide bond, a urethane bond, and a urea bond.

[0046] Examples of the cross-linking agent include compounds having two or more isocyanate groups in one molecule. When such a compound is used, the compound easily reacts with the reactive functional group of the above-described (meth)acrylic copolymer, and thus there is a tendency that adhesion and stringiness are easily suppressed.

[0047] Examples of the compound having two or more isocyanate groups in one molecule include isocyanate compounds such as 2,4-tolylene diisocyanate, 2,6-tolylene diisocyanate, 1,3-xylylene diisocyanate, 1,4-xylylene diisocyanate, diphenylmethane-4,4'-diisocyanate, diphenylmethane-2,4'-diisocyanate, 3-methyldiphenylmethane diisocyanate, hexamethylene diisocyanate, isophorone diisocyanate, dicyclohexylmethane-4,4'-diisocyanate, dicyclohexylmethane-2,4'-diisocyanate, and lysine isocyanate.

[0048] Specific examples of the compound having two or more isocyanate groups in one molecule include polyfunctional isocyanate (manufactured by Nippon Polyurethane Industry Co., Ltd., trade name "Coronate L").

[0049] The cross-linking agent may be a reaction product between the aforementioned isocyanate compound and a polyhydric alcohol having two or more hydroxy groups in one molecule (an isocyanate group-containing oligomer). Examples of the polyhydric alcohol having two or more hydroxy groups in one molecule include ethylene glycol, propylene glycol, butylene glycol, 1,6-hexanediol, 1,8-octanediol, 1,9-nonanediol, 1,10-decanediol, 1,11-undecanediol, 1,12-dodecanediol, glycerin, pentaerythritol, dipentaerythritol, 1,4-cyclohexanediol, and 1,3-cyclohexanediol.

[0050] Of these, the cross-linking agent may be a reaction product between a polyfunctional isocyanate having two or more isocyanate groups in one molecule and a polyhydric alcohol having three or more hydroxy groups in one molecule (an isocyanate group-containing oligomer). By using such an isocyanate group-containing oligomer as the cross-linking agent, there is a tendency that a photocurable adhesive layer 20 forms a denser cross-linked structure.

[0051] The content of the cross-linking agent may be, for example, 3 to 30 parts by mass, 4 to 15 parts by mass, or 5 to 10 parts by mass, with respect to the total mass of the (meth)acrylic copolymer.

[0052] <Dicing/die bonding integrated film and manufacturing method therefor>

FIG. 1 is a schematic cross-sectional view illustrating an embodiment of a dicing/die bonding integrated film. In a dicing/die bonding integrated film 1, a base material layer 10, a photocurable adhesive layer 20 composed of a photocurable adhesive, and a bonding adhesive layer 30 are stacked in this order.

[0053] (Base material layer)

The base material layer 10 is not particularly limited as long as known polymer sheets or films can be used and the base material layer is configured by a material that can be expanded in a die bonding step.

5 Examples of such a material include polyolefins such as crystalline polypropylene, amorphous polypropylene, high-density polyethylene, intermediate-density polyethylene, low-density polyethylene, very low-density polyethylene, low-density linear polyethylene, polybutene, and polymethylpentene; an ethylene-vinylacetate copolymer; an ionomer
10 resin; an ethylene-(meth)acrylic acid copolymer; an ethylene-(meth)acrylic acid ester (random or alternating) copolymer; an ethylene-propylene copolymer; an ethylene-butene copolymer; an ethylene-hexene copolymer; polyurethane; polyesters such as polyethylene terephthalate and polyethylene naphthalate; polycarbonate; polyimide;
15 polyetheretherketone; polyimide; polyetherimide; polyamide; whole aromatic polyamides; polyphenylsulfide; aramid (paper); glass; glass cloth; a fluorine resin; polyvinyl chloride; polyvinylidene chloride; a cellulose-based resin; and a silicone resin. These materials may be materials obtained by mixing a plasticizer, silica, an anti-blocking
20 material, a slip agent, an antistatic agent, and the like.

[0054] Of these, from the viewpoints of properties such as Young's modulus, stress relaxation properties, and a melting point, cost, recycle of waste materials after being used, and the like, the base material layer 10 may have a surface containing, as a main component, at least one
25 material selected from polyethylene, polypropylene, a polyethylene-polypropylene random copolymer, and a polyethylene-polypropylene

block copolymer and this surface may be in contact with the photocurable adhesive layer 20. The base material layer 10 may be a single layer and may be a multi-layer of two or more layers composed of different materials. From the viewpoint of controlling adhesiveness with the photocurable adhesive layer 20 described below, the base material layer 10 may be subjected to a surface roughening treatment such as a corona discharge treatment or a matte treatment, as necessary.

[0055] The thickness of the base material layer 10 may be, for example, 70 to 120 μm or 80 to 100 μm . When the thickness of the base material layer 10 is 70 μm or more, there is a tendency that breakage due to expansion can be further suppressed. When the thickness of the base material layer 10 is 120 μm or less, there is a tendency that a stress in pickup is likely to reach to the bonding adhesive layer and pickup property is more excellent.

[0056] (Photocurable adhesive layer)

The photocurable adhesive layer 20 is a layer composed of the aforementioned photocurable adhesive. The photocurable adhesive layer 20 is formed on the base material layer 10. Examples of the method of forming the photocurable adhesive layer 20 on the base material layer 10 include a method of preparing a varnish for forming a photocurable adhesive layer and coating this varnish on the base material layer 10 to form the photocurable adhesive layer 20 and a method of coating this varnish on a release-treated film to form the photocurable adhesive layer 20 and transferring the obtained photocurable adhesive layer 20 to the base material layer 10.

[0057] The varnish for forming a photocurable adhesive layer contains a

(meth)acrylic copolymer having a reactive functional group, a photopolymerization initiator, a cross-linking agent having two or more functional groups that can react with the reactive functional group, and an organic solvent. The organic solvent may be obtained by dissolving

5 a (meth)acrylic copolymer having a reactive functional group, a photopolymerization initiator, a cross-linking agent having two or more functional groups that can react with the reactive functional group, and may volatilize by heating. Examples of such an organic solvent include

aromatic hydrocarbons such as toluene and xylene; cyclic ethers such as

10 tetrahydrofuran and 1,4-dioxane; alcohols such as methanol, ethanol, ethylene glycol, and propylene glycol; ketones such as acetone, methyl ethyl ketone, methyl isobutyl ketone, and cyclohexanone; esters such as

methyl acetate, ethyl acetate, and γ -butyrolactone; carbonic acid esters such as ethylene carbonate and propylene carbonate; polyhydric alcohol

15 alkyl ethers such as ethylene glycol monomethyl ether, ethylene glycol dimethyl ether, propylene glycol monomethyl ether, propylene glycol monoethyl ether, and propylene glycol dimethyl ether; polyhydric alcohol

alkyl ether acetates such as ethylene glycol monomethyl ether acetate and ethylene glycol monoethyl ether acetate; and amides such as N,N-

20 dimethylformamide, N,N-dimethyl acetamide, and N-methyl-2-pyrrolidone. These may be used singly or in combination of two or more kinds thereof. The solid concentration of the varnish may be 10

to 60% by mass on the basis of the total mass of the varnish.

[0058] The thickness of the photocurable adhesive layer 20 may be, for

25 example, 1 to 200 μm , 5 to 50 μm , or 10 to 20 μm .
[0059] (Bonding adhesive layer)

The bonding adhesive layer 30 is a layer composed of a bonding adhesive. The bonding adhesive is not particularly limited as long as it is a bonding adhesive to be used in the field of die bonding films. Hereinafter, as an example of the bonding adhesive, a bonding adhesive containing an epoxy resin, an epoxy resin curing agent, and a (meth)acrylic copolymer having an epoxy group will be described. According to the bonding adhesive layer 30 composed of such a bonding adhesive, adhesiveness between a chip and a substrate and between chips are excellent, electrode embeddability, wire embeddability, and the like can be imparted, and in the die bonding step, bonding at a low temperature can be performed.

[0060] Examples of the epoxy resin include a bisphenol A type epoxy resin, a bisphenol F type epoxy resin, a bisphenol S type epoxy resin, a phenol novolak type epoxy resin, a cresol novolak type epoxy resin, a bisphenol A novolak type epoxy resin, a bisphenol F novolak type epoxy resin, a dicyclopentadiene skeleton-containing epoxy resin, a stilbene type epoxy resin, a triazine skeleton-containing epoxy resin, a fluorene skeleton-containing epoxy resin, a triphenolmethane type epoxy resin, a biphenyl type epoxy resin, a xylylene type epoxy resin, a biphenyl aralkyl type epoxy resin, a naphthalene type epoxy resin, and a diglycidyl ether compound of a polyfunctional phenol or a polycyclic aromatic compound such as anthracene. These may be used singly or in combination of two or more kinds thereof.

[0061] The epoxy resin curing agent may be, for example, a phenolic resin. The phenolic resin can be used without particular limitation as long as it has a phenolic hydroxyl group in the molecule. Examples of

the phenolic resin include novolak type phenolic resins obtained by condensation or co-condensation of phenols such as phenol, cresol, resorcin, catechol, bisphenol A, bisphenol F, phenylphenol, and aminophenol and/or naphthols such as α -naphthol, β -naphthol, and dihydroxynaphthalene with a compound having an aldehyde group such as formaldehyde in the presence of an acidic catalyst; and phenol aralkyl resins and naphthol aralkyl resins synthesized from phenols such as allylated bisphenol A, allylated bisphenol F, allylated naphthalene diol, phenol novolak, and phenol and/or naphthols with dimethoxyparaxylene or bis(methoxymethyl)biphenyl. These may be used singly or in combination of two or more kinds thereof.

[0062] The (meth)acrylic copolymer having an epoxy group may be a copolymer in which the amount of glycidyl (meth)acrylate as a raw material is adjusted to be 0.5 to 6% by mass with respect to the obtained copolymer. When this amount is 0.5% by mass or more, there is a tendency that a high adhesive force is easily obtained; on the other hand, when this amount is 6% by mass or less, there is a tendency that gelation can be suppressed. The remaining part of glycidyl (meth)acrylate may be alkyl (meth)acrylate having an alkyl group having 1 to 8 carbon atoms such as methyl (meth)acrylate, and a mixture of styrene, acrylonitrile, and the like. The alkyl (meth)acrylate may contain ethyl (meth)acrylate and/or butyl (meth)acrylate. The mixing ratio of each component can be adjusted in consideration of T_g (glass transition temperature) of the (meth)acrylic copolymer having an epoxy group thus obtained. When T_g is -10°C or higher, the tackiness of the bonding adhesive layer in the B-stage state tends to be satisfactory, and handleability tends to be

excellent. The upper limit value of Tg of the (meth)acrylic copolymer having an epoxy group may be, for example, 30°C.

[0063] The weight average molecular weight of the (meth)acrylic copolymer having an epoxy group may be 100000 or more, 300000 to 3000000, or 500000 to 2000000. When the weight average molecular weight is 3000000 or less, there is a tendency that a decrease in fillability between a semiconductor chip and a support substrate can be suppressed. The weight average molecular weight is a value in terms of polystyrene using a calibration curve of standard polystyrene by gel permeation chromatography (GPC).

[0064] The bonding adhesive may further contain, as necessary, curing accelerators such as tertiary amine, imidazoles, and quaternary ammonium salts. Examples of the curing accelerator include 2-methylimidazole, 2-ethyl-4-methylimidazole, 1-cyanoethyl-2-phenylimidazole, and 1-cyanoethyl-2-phenylimidazolium trimellitate. These may be used singly or in combination of two or more kinds thereof.

[0065] The bonding adhesive may further contain, as necessary, an 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 whisker, boron nitride, crystalline silica, and amorphous silica. These may be used singly or in combination of two or more kinds thereof.

[0066] The bonding adhesive layer 30 is formed on the photocurable adhesive layer 20. Examples of the method of forming the bonding adhesive layer 30 on the photocurable adhesive layer 20 include a method

of preparing a varnish for forming a bonding adhesive layer and coating this varnish on a release-treated film to form the bonding adhesive layer 30, and transferring the obtained bonding adhesive layer 30 to the photocurable adhesive layer 20. The varnish for forming a bonding
5 adhesive layer contains an epoxy resin, an epoxy resin curing agent, a (meth)acrylic copolymer having an epoxy group, and an organic solvent. The organic solvent may be the same as exemplified in the organic solvent to be used in the varnish for forming a photocurable adhesive layer.

10 [0067] The thickness of the bonding adhesive layer 30 may be, for example, 1 to 300 μm , 5 to 150 μm , or 10 to 100 μm .

[0068] [Influencing factor of loss work]

The loss work may be affected by an interaction (for example, a stringing phenomenon or the like) in an interface between the
15 photocurable adhesive layer and the adherend (the bonding adhesive layer). Therefore, as one of influencing factors of the loss work, the type and the content of the cross-linking agent are exemplified. For example, when the content of the cross-linking agent is decreased, the loss work is increased, and when the content of the cross-linking agent is
20 increased, there is a tendency that the loss work is decreased. Therefore, by adjusting the type and the content of the cross-linking agent, the loss work can be controlled. Furthermore, as other influencing factors of the loss work, for example, coating conditions are exemplified.

[0069] <First step>

25 In this step, first, a photocurable adhesive sheet composed of a photocurable adhesive is prepared.

[0070] The photocurable adhesive sheet is composed of a photocurable adhesive. The photocurable adhesive sheet can be obtained, for example, by preparing the aforementioned varnish for forming a photocurable adhesive layer, coating this varnish on a release-treated polyethylene terephthalate (PET) film, and removing volatile components of the varnish to form a photocurable adhesive layer. As for the photocurable adhesive sheet, a polyethylene terephthalate (PET) film may be disposed as a protective film on the photocurable adhesive layer. The size of the photocurable adhesive sheet is not particularly limited as long as the distance between chucks can be secured to be 40 mm in a tensile test described below. The thickness of the photocurable adhesive sheet can be set to be, for example, 10 μm .

[0071] Then, the tensile test is executed with respect to the photocurable adhesive sheet under the following tensile and compression conditions.

A graph of a test force with respect to displacement in the tensile test is created, and an area surrounded by a hysteresis curve thus obtained is obtained as loss work from the hysteresis curve. When the loss work is obtained, arbitrary evaluation process analysis software may be used.

[0072] (Tensile and compression conditions)

Temperature: $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$

Humidity: $55 \pm 10\%$

Distance between chucks: 40 mm

Tensile condition: Tension at 500 mm/min until the test force becomes 0.5 N

Compression condition: Compression at 500 mm/min until the displacement becomes 0 mm

[0073] <Second step>

In this step, first, a dicing/die bonding integrated film for evaluation in which a base material layer, a photocurable adhesive layer composed of a photocurable adhesive that is an evaluation target, and a bonding adhesive layer are stacked in this order is prepared.

[0074] In the dicing/die bonding integrated film for evaluation, the types of the base material layer, the photocurable adhesive layer, and the bonding adhesive layer, and the like are not particularly limited, and a dicing/die bonding integrated film which is arbitrarily selected can be used. The thickness of the photocurable adhesive layer composed of the photocurable adhesive that is an evaluation target can be set to be, for example, 10 μm . The thickness of the bonding adhesive layer can be set to be, for example, 10 μm .

[0075] Then, the photocurable adhesive layer is irradiated with ultraviolet rays under the following irradiation conditions to cure the photocurable adhesive, and thereby a cured product of the photocurable adhesive layer (a layer including the cured product of the photocurable adhesive layer) is formed. As a light source of ultraviolet rays, optimal light sources can be appropriately selected according to the type of a photopolymerization initiator to be used. The light source of ultraviolet rays is not particularly limited, and may be one selected from the group consisting of a low-pressure mercury lamp, a far-ultraviolet lamp, an excimer ultraviolet lamp, a high-pressure mercury lamp, and a metal halide lamp. Of these, the light source of ultraviolet rays is preferably a high-pressure mercury lamp having a center wavelength of 365 nm. Furthermore, in irradiation of ultraviolet rays, in order to reduce the

influence of heat emitted from the light source, a cold mirror or the like may be used together.

[0076] (Irradiation conditions)

Irradiation intensity: 70 mW/cm^2

5 Integrated quantity of light: 150 mJ/cm^2

[0077] The irradiation temperature in the irradiation conditions of ultraviolet rays may be 60°C or lower or 40°C or lower.

[0078] Finally, the peeling force (low-angle peeling strength) when the cured product of the photocurable adhesive layer is peeled off from the base material layer under the following peeling conditions is measured. In the case of peeling off the cured product of the photocurable adhesive layer from the base material layer, it is preferable that, using a peeling strength measurement device capable of adjusting a peeling angle, an adhesive tape, a support tape, and the like are pasted to the bonding
10
15 adhesive layer, and peeling-off is performed by pulling these tapes.

[0079] (Peeling conditions)

Temperature: $25^\circ\text{C} \pm 5^\circ\text{C}$

Humidity: $55 \pm 10\%$

Peeling angle: 30°

20 Peeling rate: 600 mm/min

[0080] Note that, as the peeling angle is a lower angle, there is a tendency that the influence of the base material layer in the peeling force can be eliminated, but when the peeling angle is less than 15° , the measurement is difficult. Therefore, 30° is suitable as the test condition of the low-angle peeling strength.

[0081] <Third step>

In this step, quality of the photocurable adhesive is determined on the basis of the loss work and the peeling force. Regarding numerical values of the loss work and the peeling force that are evaluation criteria, arbitrary numerical values can be set in accordance with the thickness of the semiconductor wafer, or the like.

[0082] The third step may be a step in which quality of the photocurable adhesive is determined by determining whether or not the loss work and the peeling force satisfy the following condition (a) and the following condition (b). The dicing/die bonding integrated film including the photocurable adhesive layer composed of the photocurable adhesive satisfying the following condition (a) and the following condition (b) can be suitably used in a dicing process (for example, stealth dicing or the like) applied to a semiconductor wafer having a relatively thin thickness (for example, 35 μm or less).

[0083] Condition (a): The loss work is 1.21 N·mm or more.

Condition (b): The peeling force is 0.60 N/25 mm or less.

[0084] By satisfying the condition (a), there is a tendency that chip floating in the manufacturing of a semiconductor chip is further suppressed. The loss work of the condition (a) may be 1.22 N·mm or more or 1.24 N·mm or more. The upper limit value of the loss work of the condition (a) is not particularly limited, and may be 1.40 N·mm or less.

[0085] By satisfying the condition (b), there is a tendency that pickup property in the manufacturing of a semiconductor chip is further improved. The peeling force of the condition (b) may be 0.59 N/25 mm or less or 0.58 N/25 mm or less. The lower limit value of the peeling

force of the condition (b) is not particularly limited, and may be 0.54 N/25 mm or more.

[0086] [Method for manufacturing dicing/die bonding integrated film]

The method for manufacturing a dicing/die bonding integrated film according to an embodiment includes a step in which a photocurable adhesive layer composed of a photocurable adhesive which is determined to be good by the aforementioned method for evaluating a photocurable adhesive is formed on a base material layer, and a step in which a bonding adhesive layer is formed on the photocurable adhesive layer. The base material layer and the bonding adhesive layer may be the same as those exemplified in the aforementioned method for evaluating a photocurable adhesive. The formation method of the photocurable adhesive layer and the formation method of the bonding adhesive layer may also be the same as the methods exemplified in the aforementioned method for evaluating a photocurable adhesive.

[0087] [Dicing/die bonding integrated film]

A dicing/die bonding integrated film according to an embodiment includes a base material layer, a photocurable adhesive layer composed of a photocurable adhesive which is determined to be good by the aforementioned method for evaluating a photocurable adhesive, and a bonding adhesive layer in this order. The base material layer and the bonding adhesive layer may be the same as those exemplified in the aforementioned method for evaluating a photocurable adhesive.

[0088] [Method for manufacturing semiconductor device (semiconductor package)]

FIGS. 2 and 3 are schematic cross-sectional views for describing

an embodiment of a method for manufacturing a semiconductor device. The method for manufacturing a semiconductor device according to the present embodiment includes a step in which the bonding adhesive layer 30 of the dicing/die bonding integrated film 1 obtained by the
5 aforementioned manufacturing method is pasted to a semiconductor wafer W2 (a wafer lamination step), a step in which the semiconductor wafer W2, the bonding adhesive layer 30, and the photocurable adhesive layer 20 are individualized (a dicing step), a step in which the photocurable adhesive layer 20 is irradiated with ultraviolet rays (an
10 ultraviolet irradiation step), a step in which a semiconductor element attached with a bonding adhesive layer 30a (a bonding adhesive layer-attached semiconductor element 50) is picked up from the base material layer 10 (a pickup step), and a step in which the bonding adhesive layer-attached semiconductor element 50 is bonded to a support substrate 60
15 for mounting a semiconductor element via the bonding adhesive layer 30a (a semiconductor element bonding step).

[0089] The dicing in the dicing step is not particularly limited, and examples thereof include blade dicing, laser dicing, and stealth dicing. In a case where the thickness of the semiconductor wafer W2 is set to be
20 35 μm or less, stealth dicing may be applied as the dicing. In the following description, an embodiment mainly using stealth dicing as the dicing will be specifically described.

[0090] <Modified layer formation step>

In a case where stealth dicing is applied as the dicing, the method
25 for manufacturing a semiconductor device may include a modified layer formation step before the wafer lamination step.

[0091] First, a semiconductor wafer W1 having a thickness H1 is prepared. The thickness H1 of the semiconductor wafer W1 forming a modified layer may exceed 35 μm . Subsequently, a protective film 2 is pasted on one main surface of the semiconductor wafer W1 (see FIG. 2(a)). The surface to which the protective film 2 is pasted is preferably a circuit surface of the semiconductor wafer W1. The protective film 2 may be a back grinding tape to be used in backgrinding of the semiconductor wafer. Subsequently, the inside of the semiconductor wafer W1 is irradiated with laser light to form a modified layer 4 (see FIG. 2(b)) and the surface (rear surface) of the semiconductor wafer W1 opposite to the surface to which the protective film 2 is pasted is subjected to backgrinding and polishing, thereby producing the semiconductor wafer W2 having the modified layer 4 (see FIG. 2(c)). A thickness H2 of the semiconductor wafer W2 thus obtained may be 35 μm or less.

[0092] <Wafer lamination step>

Then, the bonding adhesive layer 30 of the dicing/die bonding integrated film 1 is disposed in a predetermined apparatus. Subsequently, the dicing/die bonding integrated film 1 is pasted to a main surface Ws of the semiconductor wafer W2 via the bonding adhesive layer 30 (see FIG. 2(d)), and the protective film 2 of the semiconductor wafer W2 is peeled off (see FIG. 2(e)).

[0093] <Dicing step>

Next, at least the semiconductor wafer W2 and the bonding adhesive layer 30 are individualized by dicing (see FIG. 3(f)). In a case where stealth dicing is applied as the dicing, individualization can be performed by cool expansion and heat shrinkage.

[0094] <Ultraviolet irradiation step>

Then, the photocurable adhesive layer 20 is irradiated with ultraviolet rays to cure the photocurable adhesive in the photocurable adhesive layer 20, and thereby a cured product of the photocurable adhesive layer (a layer including the cured product of the photocurable adhesive) is formed (see FIG. 3(g)). Thereby, the adhesive force between the photocurable adhesive layer 20 and the bonding adhesive layer 30 can be reduced. In ultraviolet irradiation, ultraviolet rays having a wavelength of 200 to 400 nm are preferably used. The ultraviolet irradiation conditions are preferably adjusted so that the illumination and the irradiance level are adjusted to be 30 to 240 mW/cm² and 200 to 500 mJ/cm², respectively.

[0095] <Pickup step>

Next, by expanding the base material layer 10, while the diced bonding adhesive layer-attached semiconductor elements 50 are separated from each other, the bonding adhesive layer-attached semiconductor element 50, which has been thrust up by a needle 42 from the side of the base material layer 10, is sucked by a suction collet 44 so as to be picked up from a cured product 20ac of the photocurable adhesive layer (see FIG. 3(h)). Note that, the bonding adhesive layer-attached semiconductor element 50 has a semiconductor element Wa and the bonding adhesive layer 30a. The semiconductor element Wa is obtained by dividing the semiconductor wafer W2 by dicing, and the bonding adhesive layer 30a is obtained by dividing the bonding adhesive layer 30 by dicing. The cured product 20ac of the photocurable adhesive layer is obtained by dividing the cured product of the photocurable adhesive

layer by dicing. The cured product 20ac of the photocurable adhesive layer may remain on the base material layer 10 when the bonding adhesive layer-attached semiconductor element 50 is picked up. In the pickup step, it is not necessary to expand the base material layer, but by
5 expanding the base material layer, pickup property can be further improved.

[0096] The thrust-up amount by the needle 42 can be appropriately set. Further, from the viewpoint of securing sufficient pickup property even with respect to an extremely thin wafer, for example, two-stage or three-
10 stage pickup may be performed. Furthermore, the bonding adhesive layer-attached semiconductor element 50 may be picked up by a method other than the method using the suction collet 44.

[0097] <Semiconductor element bonding step>

After picking up the bonding adhesive layer-attached
15 semiconductor element 50, the bonding adhesive layer-attached semiconductor element 50 is bonded to the support substrate 60 for mounting a semiconductor element via the bonding adhesive layer 30a by thermal compression bonding (see FIG. 3(i)). A plurality of the bonding adhesive layer-attached semiconductor elements 50 may be bonded to the
20 support substrate 60 for mounting a semiconductor element.

[0098] FIG. 4 is a cross-sectional view schematically illustrating an embodiment of a semiconductor device. A semiconductor device 100 illustrated in FIG. 4 can be manufactured by the manufacturing method further including, in addition to the above-described step, a step in which
25 the semiconductor element Wa and the support substrate 60 for mounting a semiconductor element are electrically connected by wire bonds 70 and

a step in which the semiconductor element Wa is resin-sealed on a surface 60a of the support substrate 60 for mounting a semiconductor element using a resin sealing material 80. A solder ball 90 for electrical connection with an external substrate (mother board) may be formed on the surface of the support substrate 60 for mounting a semiconductor element that is opposite to the surface 60a.

Examples

[0099] Hereinafter, the present invention will be described more specifically by way of Examples; however, the present invention is not intended to be limited to these Examples. Note that, unless otherwise specified, commercially available reagents were used as compounds.

[0100] [Preparation of dicing/die bonding integrated film]

(Preparation of (meth)acrylic copolymer solution)

To a 2000-mL autoclave equipped with a three-one motor, a stirring blade, and a nitrogen gas introducing pipe, 79 parts by mass of 2-ethylhexyl acrylate (2EHA), 19 parts by mass of 2-hydroxyethyl acrylate (HEA), and 2 parts by mass of methacrylic acid (MAA) were added, and 127 parts by mass of ethyl acetate and 0.04 parts by mass of azobisisobutyronitrile were further added. This was stirred until being homogeneous, and bubbling was executed for 60 minutes at a flow rate of 500 ml/min to remove dissolved oxygen in the system. Then, the temperature was increased to 80°C over an hour, and polymerization was performed for 6 hours while maintaining the temperature at 80°C. Thereafter, the reaction solution was transferred to a 2000-mL pressurizing oven equipped with a three-one motor, a stirring blade, and a nitrogen gas introducing pipe, heated under conditions of 120°C and

0.28 MPa for 6 hours, and then cooled to room temperature (25°C, the same applies hereinafter). Then, the reaction solution was diluted by further adding 89 parts by mass of ethyl acetate. 0.005 parts by mass of dibutylhydroxytoluene as a polymerization inhibitor and 0.011 parts by mass of dioctyltin dilaurate as a urethane-forming catalyst were added thereto, 14 parts by mass of 2-methacryloxyethyl isocyanate (manufactured by Showa Denko K.K., trade name "Karenc MOI") as a compound having a chain polymerizable functional group was added, and the mixture was reacted at 70°C for 12 hours and cooled to room temperature. Thereafter, ethyl acetate was added so that the content of non-volatile matters (solid content) became 35% by mass, thereby obtaining a (meth)acrylic copolymer solution having a hydroxy group as a reactive functional group.

[0101] The acid value and the hydroxyl value of the (meth)acrylic copolymer in the (meth)acrylic copolymer solution were measured according to JIS K0070. The acid value was 10.2 mg KOH/g, and the hydroxyl value was 80.0 mg KOH/g. Furthermore, the obtained acrylic resin was vacuum-dried at 60°C overnight, the obtained solid content was subjected to elemental analysis with a full automatic elemental analysis apparatus varioEL manufactured by Elementar, and the content of the introduced 2-methacryloxyethyl isocyanate was calculated from the content of nitrogen. The content of 2-methacryloxyethyl isocyanate was 0.90 mmol/g. Further, the weight average molecular weight (M_w) in terms of polystyrene was measured by using SD-8022/DP-8020/RI-8020 manufactured by Tosoh Corporation as a GPC apparatus, Gelpack GL-A150-S/GL-A160-S manufactured by Hitachi Chemical Co., Ltd. as

a column, and tetrahydrofuran as an eluent. The weight average molecular weight was 270000.

[0102] <Production Example 1: Production of photocurable adhesive sheet A and dicing/die bonding integrated film A>

5 (Preparation of photocurable adhesive A)

100 parts by mass in terms of solid content of a (meth)acrylic copolymer solution prepared above as a (meth)acrylic copolymer having a reactive functional group, 0.6 parts by mass of 1-hydroxycyclohexyl phenyl ketone (manufactured by Ciba Specialty Chemicals Co., Ltd.,
10 IRGACURE 184) and 0.3 parts by mass of bis(2,4,6-trimethyl benzoyl)-phenyl phosphine oxide (manufactured by Ciba Specialty Chemicals Co., Ltd., IRGACURE 819) as photopolymerization initiators, and 6.8 parts by mass of polyfunctional isocyanate (manufactured by Nippon Polyurethane Industry Co., Ltd., trade name "Coronate L", solid content:
15 75%) as a cross-linking agent were mixed. Ethyl acetate was added to this mixture so that the total of solid contents became 25% by mass, and was uniformly stirred for 10 minutes, thereby obtaining a varnish for a photocurable adhesive A.

[0103] (Production of photocurable adhesive sheet)

20 The aforementioned varnish for a photocurable adhesive A was coated using a coater on a polyethylene terephthalate (PET) film having one release-treated surface and a thickness of 20 μm so that the thickness of the photocurable adhesive layer (photocurable adhesive sheet) after drying became 10 μm . The coating was performed under conditions of
25 a speed of 3.0 m/min, a first drying furnace temperature of 80°C, and a second drying furnace temperature of 80°C. A PET film having a

thickness of 38 μm was disposed on the obtained photocurable adhesive layer (photocurable adhesive sheet), thereby obtaining the photocurable adhesive layer (photocurable adhesive sheet) interposed between two PET films.

5 [0104] (Production of dicing film)

The aforementioned varnish for a photocurable adhesive A was coated on a polyethylene terephthalate (PET) film having one release-treated surface and a width of 350 mm, a length of 400 mm, and a thickness of 38 μm while adjusting a gap so that the thickness of the photocurable adhesive layer after drying became 10 μm , and the varnish for forming a photocurable adhesive layer was heated and dried at 80°C to 100°C for 3 minutes. Thereafter, a polyolefin film subjected to a corona discharge treatment (base material layer, thickness: 90 μm) was laminated to one surface, curing was performed under conditions of 40°C and 72 hours, and a cross-linking treatment was performed, thereby obtaining a dicing film including the base material layer and the photocurable adhesive layer. Note that, the cross-linking treatment was performed using FT-IR spectrum while checking the proceeding of curing.

15 [0105] (Production of die bonding film)

20 Cyclohexanone was added to 55 parts by mass of YDCN-703 (manufactured by Tohto Kasei Co., Ltd., trade name, cresol novolak type epoxy resin, epoxy equivalent: 210, molecular weight: 1200, softening point: 80°C) as an epoxy resin, 45 parts by mass of MILEX XLC-LL (manufactured by Mitsui Chemicals, Inc., trade name, hydroxyl equivalent: 175, water absorption percentage: 1.8%, heating mass decrease rate at 350°C: 4%) as a phenolic resin, 1.7 parts by mass of

25

NUCA-189 (manufactured by Nippon Unicar Company Limited, trade name, γ -mercaptopropyl trimethoxysilane) and 3.2 parts by mass of NUCA-1160 (manufactured by Nippon Unicar Company Limited, trade name, γ -ureidopropyl triethoxysilane) as silane coupling agents, and 32 parts by mass of AEROSIL R972 (silica filler in which the silica surface is covered with dimethyldichlorosilane and which is hydrolyzed in a reactor set at 400°C and surface-modified by an organic group such as a methyl group, manufactured by NIPPON AEROSIL CO., LTD., trade name, average particle size: 0.016 μm) as a filler, and the resultant product was stirred and mixed and further kneaded using a bead mill for 90 minutes. 280 parts by mass of HTR-860P-3 (manufactured by Nagase ChemteX Corporation, trade name, weight average molecular weight: 800000, acrylic rubber containing 3% by mass of glycidyl acrylate or glycidyl methacrylate) as acrylic rubber and 0.5 parts by mass of CUREZOL 2PZ-CN (manufactured by SHIKOKU CHEMICALS CORPORATION, trade name, 1-cyanoethyl-2-phenylimidazole) as a curing accelerator were added to the obtained mixture, mixed under stirring, and subjected to vacuum deaeration, thereby obtaining a varnish for forming a bonding adhesive layer. The obtained varnish for forming a bonding adhesive layer was applied onto a release-treated polyethylene terephthalate (PET) film having a thickness of 38 μm and heated and dried at 140°C for 5 minutes to form a coating film in a B-stage state having a thickness of 10 μm , thereby producing a die bonding film including the bonding adhesive layer.

[0106] (Production of dicing/die bonding integrated film)

The die bonding film produced above was cut for each PET film

into a size that was easily handled. The photocurable adhesive layer of the dicing film from which the PET film was peeled off was laminated to the bonding adhesive layer of the cut die bonding film, thereby obtaining a dicing/die bonding integrated film A. Lamination was performed in a
5 clean room (in a clean room at a temperature of 23°C and a humidity of 50%) using a laminating machine.

[0107] <Production Example 2: Production of photocurable adhesive sheet B and dicing/die bonding integrated film B>

A photocurable adhesive sheet B and a dicing/die bonding
10 integrated film B were obtained in the same manner as in Production Example 1, except that the content of the cross-linking agent was changed from 6.8 parts by mass to 7.2 parts by mass.

[0108] <Production Example 3: Production of photocurable adhesive sheet C and dicing/die bonding integrated film C>

A photocurable adhesive sheet C and a dicing/die bonding
15 integrated film C were obtained in the same manner as in Production Example 1, except that the content of the cross-linking agent was changed from 6.8 parts by mass to 7.6 parts by mass.

[0109] <Production Example 4: Production of photocurable adhesive
20 sheet D and dicing/die bonding integrated film D>

A photocurable adhesive sheet D and a dicing/die bonding integrated film D were obtained in the same manner as in Production Example 1, except that the content of the cross-linking agent was changed from 6.8 parts by mass to 4.0 parts by mass.

[0110] <Production Example 5: Production of photocurable adhesive
25 sheet E and dicing/die bonding integrated film E>

A photocurable adhesive sheet E and a dicing/die bonding integrated film E were obtained in the same manner as in Production Example 1, except that the content of the cross-linking agent was changed from 6.8 parts by mass to 6.4 parts by mass.

5 [0111] <Production Example 6: Production of photocurable adhesive sheet F and dicing/die bonding integrated film F>

A photocurable adhesive sheet F and a dicing/die bonding integrated film F were obtained in the same manner as in Production Example 1, except that the content of the cross-linking agent was changed
10 from 6.8 parts by mass to 8.0 parts by mass.

[0112] [Measurement of loss work]

Each of the photocurable adhesive sheets A to F was cut into a size of 50 mm × 50 mm, the photocurable adhesive layer was peeled off from the photocurable adhesive sheet, and the photocurable adhesive layer was uniformly curled into a columnar shape from one side. A
15 curing tape (manufactured by TERAOKA SEISAKUSHO CO., LTD.) was pasted to both ends of 20 mm from the central portion (5 mm from the distal end), and the tensile test was executed with respect to the photocurable adhesive layer using a high-speed tensile tester Tensilon
20 (manufactured by A&D Company, Limited). The tensile test was performed at 25°C ± 5°C and a humidity of 55 ± 10%, and the distance between chucks was set to be 40 mm. In the tensile test, the photocurable adhesive layer was pulled at 500 mm/min until the test force became 0.5 N, and was compressed at 500 mm/min until the displacement
25 became 0 mm. A graph of a test force (N) with respect to displacement (mm) was created, and an area surrounded by a hysteresis curve thus

obtained was obtained as loss work. TACT (manufactured by A&D Company, Limited) was used as data processing analysis software. The results are shown in Table 1. Furthermore, sufficiency of the condition (a) (the loss work is 1.21 N·mm or more) is also shown in Table 1.

5 [0113] [Measurement of peeling force]

<Production of measurement sample>

Each of the dicing/die bonding integrated films A to F was cut into pieces having a width of 30 mm and a length of 200 mm, the PET film on the side of the bonding adhesive layer of the die bonding film was peeled off, and an adhesive film (manufactured by Oji Tac Co., Ltd.) was
10 pasted to the bonding adhesive layer side using a roller and then cut into a size having a width of 25 mm and a length of 170 mm. Then, the photocurable adhesive layer was irradiated with ultraviolet rays from the side of the base material layer (polyolefin film) of the cut adhesive film-
15 attached dicing/die bonding integrated film using an ultraviolet irradiation device (manufactured by GS Yuasa Corporation, UV SYSTEM, ultraviolet rays having a center wavelength of 365 nm) at an irradiation temperature of 40°C or lower, an irradiation intensity of 70 mW/cm², and an integrated quantity of light of 150 mJ/cm², and thereby
20 a cured product of the photocurable adhesive layer was formed to obtain a measurement sample.

[0114] <Measurement of peeling force>

The peeling force (low-angle (30°) peeling strength) of the measurement sample produced above when the cured product of the photocurable adhesive layer was peeled off from the base material layer
25 at a temperature of 25°C ± 5°C, a humidity of 55 ± 10%, a peeling angle

of 30°, and a peeling rate of 600 mm/min was measured using an angle-adjustable-type adhesive/film peeling analyzer VPA-2S (manufactured by Kyowa Interface Science Co., Ltd.). The same measurement was performed three times, and an average value thereof was regarded as the low-angle peeling strength. The results are shown in Table 1. Furthermore, sufficiency of the condition (b) (the peeling force is 0.60 N/25 mm or less) is also shown in Table 1.

[0115] [Evaluation of chip floating and pickup property]

Chip floating (adhesiveness between the bonding adhesive layer and the photocurable adhesive layer before curing in expansion) and pickup property of the obtained dicing/die bonding integrated films A to F of Production Examples 1 to 6 were evaluated.

[0116] <Production of evaluation sample>

(Modified layer formation)

A back grinding tape was pasted to one surface of a semiconductor wafer (silicon wafer (thickness: 750 μm, outside diameter: 12 inch)) to obtain a back grinding tape-attached semiconductor wafer. The surface of the semiconductor wafer opposite to the side to which the back grinding tape was pasted was irradiated with laser light to form a modified layer inside the semiconductor wafer. Laser irradiation conditions are as follows.

[0117] Laser oscillator type: Semiconductor laser-excited Q-switched solid laser

Wavelength: 1342 nm

Oscillation type: pulsed

Frequency: 90 kHz

Output: 1.7 W

Movement speed of mounting stage of semiconductor wafer: 700 mm/sec

[0118] Then, the surface of the semiconductor wafer opposite to the side to which the back grinding tape was pasted was subjected to backgrinding and polishing to obtain a semiconductor wafer having a thickness of 30 μm .

[0119] (Wafer lamination)

The PET film of the dicing/die bonding integrated film was peeled off and the bonding adhesive layer was pasted to the surface of the semiconductor wafer opposite to the side to which the back grinding tape was pasted.

[0120] (Dicing)

Then, a dicing/die bonding integrated film-attached semiconductor wafer having a modified layer was fixed to an expanding apparatus. Then, the dicing film was expanded under the following conditions, and the semiconductor wafer, the bonding adhesive layer, and the photocurable adhesive layer were individualized. Note that, in evaluation of chip floating described below, this individualized sample before ultraviolet irradiation was used as an evaluation sample.

[0121] Device: manufactured by DISCO Corporation, trade name "DDS2300 Fully Automatic Die Separator"

Cool expansion conditions:

temperature: -15°C , height: 9 mm, cooling time: 90 sec, speed: 300 mm/sec, standby time: 0 sec

Heat shrinkage (heat expansion) conditions:

temperature: 220°C, height: 7 mm, holding time: 15 sec, speed:
30 mm/sec, heater speed: 7°C/sec

[0122] (Ultraviolet irradiation)

The photocurable adhesive layer of the individualized
semiconductor wafer was irradiated with ultraviolet rays having a center
wavelength of 365 nm at an irradiation intensity of 70 mW/cm² and an
integrated quantity of light of 150 mJ/cm² to form a cured product of the
photocurable adhesive layer. In evaluation of pickup property described
below, the individualized sample after ultraviolet irradiation was used as
an evaluation sample.

[0123] <Evaluation of chip floating>

The evaluation sample produced above was used and observed
from the semiconductor wafer side with a microscope, and thereby the
adhesiveness between the bonding adhesive layer and the photocurable
adhesive layer was evaluated as chip floating. In observation with the
microscope, the observation was conducted with respect to a peripheral
portion and a center portion of the semiconductor wafer, and a floating
region with respect to a unit semiconductor chip area was designated as
a peeled area. A case where the peeled area between the bonding
adhesive layer and the photocurable adhesive layer was less than 15% of
the entire area was evaluated as "A", a case where the peeled area between
the bonding adhesive layer and the photocurable adhesive layer was 15%
or more and less than 20% of the entire area was evaluated as "B", and a
case where the peeled area between the bonding adhesive layer and the
photocurable adhesive layer was 20% or more of the entire area was
evaluated as "C". The results are shown in Table 1.

[0124] <Evaluation of pickup property>

The individualized sample produced above after ultraviolet irradiation was used and evaluated using a flexible die bonder DB-730 (manufactured by Hitachi High-Tech Corporation, trade name). A collet for pickup having a size of 12.21×5.93 mm was used. A three-stage thrust-up method was adopted, the first thrust-up, the second thrust-up, and the third thrust-up were performed in a size of 11.29×5.29 mm and a speed of 1 mm/sec, a size of 9.57×3.57 mm and a speed of 10 mm/sec, and a size of 8.41×2.41 mm and a speed of 20 mm/sec, respectively, and the thrust-up height was set to 350 μm . When 1000 chips were continuously picked up, a case where the ratio of occurrence of chip crack, pickup mistake, or the like was less than 0.5% was regarded as "A", and a case where the ratio of occurrence thereof was 0.5% or more was regarded as "B". The results are shown in Table 1.

[0125] Table 1

	Production Example 1	Production Example 2	Production Example 3	Production Example 4	Production Example 5	Production Example 6
Photocurable adhesive film	A	B	C	D	E	F
Dicing/die bonding integrated film	A	B	C	D	E	F
(Meth)acrylic copolymer solution	100	100	100	100	100	100
Photopolymerization initiator	1	1	1	1	1	1
Cross-linking agent	6.8	7.2	7.6	4.0	6.4	8.0
Loss work (N·mm)	1.29	1.26	1.24	Un-measurable	1.49	1.20
Sufficiency of condition (a)	Sufficient	Sufficient	Sufficient	-	Sufficient	Insufficient
Peeling force (low-angle peeling strength) (N/25 mm)	0.58	0.55	0.54	1.02	0.63	0.53
Sufficiency of condition (b)	Sufficient	Sufficient	Sufficient	Insufficient	Insufficient	Sufficient
Evaluation of chip floating	A	A	A	A	A	B
Evaluation of pickup property	A	A	A	B	B	B

[0126] As shown in Table 1, the dicing/die bonding integrated films A to C of Production Examples 1 to 3 had loss work of 1.21 N·mm or more and a peeling force of 0.60 N/25 mm or less and satisfied both the condition (a) and the condition (b). These dicing/die bonding integrated films A to C of Production Examples 1 to 3 were excellent in chip floating and pickup property. On the other hand, it was found that the dicing/die bonding integrated films D to F of Production Examples 4 to 6 not satisfying both the condition (a) and the condition (b) were not sufficient in chip floating property and pickup property.

Reference Signs List

[0127] 1: dicing/die bonding integrated film, 2: protective film, 4: modified layer, 10: base material layer, 20: photocurable adhesive layer, 20ac: cured product of photocurable adhesive layer, 30, 30a: bonding adhesive layer, 42: needle, 44: suction collet, 50: bonding adhesive layer-attached semiconductor element, 60: support substrate for mounting semiconductor element, 70: wire bond, 80: resin sealing material, 90: solder ball, W1, W2: semiconductor wafer, H1: thickness of semiconductor wafer W1, H2: thickness of semiconductor wafer W2, 100: semiconductor device.

CLAIMS

1. A method for evaluating a photocurable adhesive to be used in a dicing/die bonding integrated film, the method comprising:

5 a first step in which a photocurable adhesive sheet composed of a photocurable adhesive is prepared, a tensile test is performed with respect to the photocurable adhesive sheet under the following tensile and compression conditions to create a graph of a test force with respect to displacement, and an area surrounded by a hysteresis curve thus obtained is obtained as loss work from the hysteresis curve;

10 a second step in which a dicing/die bonding integrated film in which a base material layer, a photocurable adhesive layer composed of a photocurable adhesive, and a bonding adhesive layer are stacked in this order is prepared, the photocurable adhesive layer is irradiated with ultraviolet rays under the following irradiation conditions to form a cured product of the photocurable adhesive layer, and a peeling force when the bonding adhesive layer and the cured product of the photocurable adhesive layer are peeled apart under the following peeling conditions is measured; and

15 a third step in which quality of the photocurable adhesive is determined on the basis of the loss work and the peeling force.

20 (Tensile and compression conditions)

Temperature: $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$

Humidity: $55 \pm 10\%$

Distance between chucks: 40 mm

25 Tensile condition: Tension at 500 mm/min until the test force becomes 0.5 N

Compression condition: Compression at 500 mm/min until the displacement becomes 0 mm

(Irradiation conditions)

Irradiation intensity: 70 mW/cm²

5 Integrated quantity of light: 150 mJ/cm²

(Peeling conditions)

Temperature: 25°C ± 5°C

Humidity: 55 ± 10%

Peeling angle: 30°

10 Peeling rate: 600 mm/min

2. The method for evaluating a photocurable adhesive according to claim 1, wherein the third step is a step in which quality of the photocurable adhesive is determined by determining whether or not the loss work and the peeling force satisfy the following condition (a) and the following condition (b).

Condition (a): The loss work is 1.21 N·mm or more.

Condition (b): The peeling force is 0.60 N/25 mm or less.

3. A method for manufacturing a dicing/die bonding integrated film, the method comprising:

20 forming a photocurable adhesive layer composed of a photocurable adhesive which is determined to be good by the method for evaluating a photocurable adhesive according to claim 1 or 2 on a base material layer; and

forming a bonding adhesive layer on the photocurable adhesive layer.

4. A method for manufacturing a semiconductor device, the method

comprising:

pasting the bonding adhesive layer of the dicing/die bonding integrated film obtained by the manufacturing method according to claim 3 to a semiconductor wafer;

5 individualizing at least the semiconductor wafer and the bonding adhesive layer by dicing;

irradiating the photocurable adhesive layer with ultraviolet rays to form a cured product of the photocurable adhesive layer;

10 picking up a semiconductor element attached with the bonding adhesive layer from the cured product of the photocurable adhesive layer; and

bonding the semiconductor element to a support substrate for mounting a semiconductor element via the bonding adhesive layer.

5. The manufacturing method according to claim 4, wherein a
15 thickness of the semiconductor wafer is 35 μm or less.

6. The manufacturing method according to claim 4 or 5, wherein stealth dicing is applied as the dicing.

7. A dicing/die bonding integrated film comprising:

a base material layer;

20 a photocurable adhesive layer composed of a photocurable adhesive which is determined to be good by the method for evaluating a photocurable adhesive according to claim 2; and

a bonding adhesive layer in this order.