

DICING TAPE-COMBINED ADHESIVE SHEET

Technical Field

[0001]

The present invention relates to dicing tape-combined adhesive sheet usable in semiconductor device production processes.

Background Art

[0002]

In some semiconductor device production processes, adhesive film-bearing semiconductor chips may be obtained through laminating a work semiconductor wafer onto a dicing tape-combined adhesive sheet having a corresponding size, and dicing the resulting semiconductor wafer into chips. A known example of such dicing tape-combined adhesive sheet is a dicing tape-combined back surface protective film.

[0003]

The dicing tape-combined back surface protective film typically includes a dicing tape and a back surface protective film. The dicing tape has a multilayer structure including a substrate and a pressure-sensitive adhesive layer. The back surface protective film is in intimate contact with the pressure-sensitive adhesive layer of the dicing tape and is thermally curable (thermosetting). Such dicing tape-combined back surface protective film is used

typically by a procedure as follows. Initially, a semiconductor wafer is laminated onto the back surface protective film of the dicing tape-combined back surface protective film. Next, the semiconductor wafer, while being held by the dicing tape-combined back surface protective film, is diced by blade dicing into semiconductor chips (dicing step). In the dicing step, together with the semiconductor wafer, the back surface protective film on the dicing tape is also diced (cut) so as to give adhesive film pieces each of which adheres to a corresponding semiconductor chip. Next, after a cleaning step, the semiconductor chips each bearing an adhesive film and being disposed on the dicing tape are picked up from the dicing tape (picking-up step). In this step, the adhesive film in the adhesive film-bearing semiconductor chip to be picked up has to be appropriately peeled off (unsecured) from the pressure-sensitive adhesive layer of the dicing tape. The dicing tape-combined back surface protective film may be used typically by the above procedure in the process of yielding a semiconductor chip with an adhesive film, where the adhesive film is to protect the back surface of the semiconductor chip and has a size corresponding to the chip. For example, Japanese Unexamined Patent Application Publication (JP-A) No. 2011-151360 and PCT International Publication Number WO2014/092200 disclose techniques

relating to such dicing tape-combined back surface protective films. The contents of Japanese Unexamined Patent Application Publication (JP-A) No. 2011-151360 and PCT International Publication Number WO2014/092200 are incorporated herein by reference in their entirety.

Summary of Invention

Technical Problem

[0005]

Conventionally, a back surface protective film, which is thermally curable, on a dicing tape in a dicing tape-combined back surface protective film is laminated onto a semiconductor wafer and is thermally cured by heating, so as to have higher adhesion to a wafer. However, such thermal curing of the back surface protective film causes the back surface protective film to have higher adhesion also to the dicing tape or to the pressure-sensitive adhesive layer of the dicing tape. The increase in adhesion may impede the peeling of the adhesive film of the adhesive film-bearing semiconductor chip from the pressure-sensitive adhesive layer of the dicing tape typically in a picking-up step as described above, and, accordingly, may impede the pick-up of the adhesive film-bearing semiconductor chip.

[0006]

The back surface protective thermosetting film, which

is uncured in the dicing tape-combined back surface protective film, tends to have gradually increased adhesion to the pressure-sensitive adhesive layer of the dicing tape, with an increasing storage period of the dicing tape-combined back surface protective film before use. Such increase in adhesion may impede the peeling of the adhesive film of the adhesive film-bearing semiconductor chip from the pressure-sensitive adhesive layer of the dicing tape and, accordingly, may impede the pick-up of the adhesive film-bearing semiconductor chip, typically in a picking-up step as described above.

[0007]

The present invention has been made under these circumstances and has an object to provide a dicing tape-combined adhesive sheet which is suitable for satisfactory pick-up of adhesive film-bearing semiconductor chips from a dicing tape.

Solution to Problem

[0008]

The present invention provides, in an embodiment, a dicing tape-combined adhesive sheet. This dicing tape-combined adhesive sheet includes a dicing tape and an adhesive sheet. The dicing tape has a multilayer structure including a substrate, and a radiation-curable pressure-sensitive adhesive layer that offers an adhesive face. The

adhesive sheet has a multilayer structure including a laser mark layer that offers a face to be marked, and an adhesive layer that offers a work-mounting face (face on which the work is to be mounted). The laser mark layer of the adhesive sheet removably adheres to the pressure-sensitive adhesive layer, or the adhesive face thereof, of the dicing tape. In the adhesive sheet, the surface defined by the adhesive layer has a peel adhesion strength to a silicon wafer of 5 N/10 mm or more, preferably 6 N/10 mm or more, and more preferably 7 N/10 mm or more, in a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min. The surface defined by the laser mark layer in the adhesive sheet has a peel adhesion strength to a silicon wafer of 0.2 N/10 mm or less, preferably 0.1 N/10 mm or less, and more preferably 0.07 N/10 mm or less, in a peel test under the conditions. The dicing tape-combined adhesive sheet has a first peel adhesion strength between the pressure-sensitive adhesive layer after radiation curing and the adhesive sheet of 0.15 N/20 mm or less, preferably 0.13 N/20 mm or less, and more preferably 0.09 N/20 mm or less, in a peel test under the conditions. The dicing tape-combined adhesive sheet has a difference between a second peel adhesion strength and the first peel adhesion strength of 0.12 N/20 mm or less, preferably 0.1 N/20 mm or less, and more preferably 0.07 N/20 mm or less, where the second peel

adhesion strength is a peel adhesion strength between the pressure-sensitive adhesive layer after radiation curing and the adhesive sheet after the storage of the dicing tape-combined adhesive sheet at 50°C for 9 days and is determined in a peel test under the conditions. The dicing tape-combined adhesive sheet having such configuration is usable in a semiconductor device production process. Specifically, the dicing tape-combined adhesive sheet according to the embodiment of the present invention is usable as a dicing tape-combined back surface protective film for providing a semiconductor chip with an adhesive film having a size corresponding to the chip, so as to protect the semiconductor chip back surface, where the adhesive sheet in the dicing tape-combined back surface protective film has a configuration of a so-called back surface protective film.

[0009]

In the adhesive sheet of the dicing tape-combined adhesive sheet, the surface defined by the adhesive layer has a peel adhesion strength to a silicon wafer of 5 N/10 mm or more, preferably 6 N/10 mm or more, and more preferably 7 N/10 mm or more, in a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min, as described above. The configuration, where the adhesive sheet has this level of high peel adhesion strength to a silicon wafer, is suitable for actually allowing the dicing tape-combined

adhesive sheet or the adhesive sheet thereof to hold a work such as a semiconductor wafer satisfactorily. The dicing tape-combined adhesive sheet, which has such configuration, does not require curing by heating of the adhesive sheet after lamination onto the work so as to have higher adhesion to the work, and is therefore suitable for avoiding or restraining increase in adhesion of the adhesive sheet to the pressure-sensitive adhesive layer of the dicing tape. Such dicing tape-combined adhesive sheet is suitable for actually providing satisfactory pick-up of adhesive film-bearing semiconductor chips from the dicing tape typically in a picking-up step as described above.

[0010]

In the adhesive sheet of the dicing tape-combined adhesive sheet, the surface defined by the laser mark layer has a peel adhesion strength to a silicon wafer of 0.2 N/10 mm or less, preferably 0.1 N/10 mm or less, and more preferably 0.07 N/10 mm or less, in a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min, as described above. The dicing tape-combined adhesive sheet has a peel adhesion strength (first peel adhesion strength) between the pressure-sensitive adhesive layer after radiation curing and the adhesive sheet of 0.15 N/20 mm or less, preferably 0.13 N/20 mm or less, and more preferably 0.09 N/20 mm or less, in a peel test under the conditions,

as described above. These configurations relating to low peel adhesion strength are suitable for surely providing removability (peelability) of the adhesive sheet from the pressure-sensitive adhesive layer of the dicing tape. Accordingly, these configurations are suitable for actually providing satisfactory pick-up of adhesive film-bearing semiconductor chips from the dicing tape typically in a picking-up step as described above. In addition, these configurations relating to low peel adhesion strength are advantageous for avoiding excessive increase in adhesion of the adhesive sheet to the pressure-sensitive adhesive layer of the dicing tape, even when the adhesion increases with time typically during storage period of the dicing tape-combined adhesive sheet before use. These configurations contribute to control of the difference between the second peel adhesion strength and the first peel adhesion strength to be 0.12 N/20 mm or less, preferably 0.1 N/20 mm or less, and more preferably 0.07 N/20 mm or less, where the second peel adhesion strength is a peel adhesion strength between the pressure-sensitive adhesive layer after radiation curing and the adhesive sheet after the storage of the dicing tape-combined adhesive sheet at 50°C for 9 days and is determined in a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min. Specifically, the configurations relating to low peel adhesion strength are advantageous for

surely providing storage stability of adhesion between the pressure-sensitive adhesive layer of the dicing tape and the adhesive sheet or the laser mark layer of the adhesive sheet. The avoidance of excessive increase in adhesion of the adhesive sheet to the pressure-sensitive adhesive layer of the dicing tape, even if the adhesion increases with time, contributes to actualization of satisfactory pick-up of adhesive film-bearing semiconductor chips from the dicing tape typically in a picking-up step as described above.

[0011]

As described above, the dicing tape-combined adhesive sheet according to the embodiment of the present invention is suitable typically as a dicing tape-combined back surface protective film for actually providing satisfactory pick-up of adhesive film-bearing semiconductor chips from the dicing tape.

[0012]

In the adhesive sheet, the laser mark layer is preferably a thermally cured thermosetting layer (thermosetting layer after thermal curing). Such a configuration is advantageous for restraining time-related increase in adhesion of the adhesive sheet to the pressure-sensitive adhesive layer of the dicing tape. In addition, the configuration, where the laser mark layer is a thermoset layer, is suitable for surely providing visibility of marked

information, when the adhesive sheet undergoes a high-temperature process such as a so-called reflow process after the information is marked on the surface defined by the laser mark layer of the adhesive sheet by laser marking.

[0013]

In the adhesive sheet, the adhesive layer is preferably a thermoplastic layer. Such configuration contributes to actualization of a high peel adhesion strength of the adhesive sheet, namely, high adhesiveness to the work such as a wafer. Assume that the laser mark layer is a thermosetting layer, and the adhesive layer is a thermoplastic layer in the adhesive sheet of the dicing tape-combined adhesive sheet. This configuration is more preferred for actually allowing the adhesive sheet to be cleaved satisfactorily in an after-mentioned expanding step for cleaving, as compared with the case where the adhesive sheet includes, for example, a single thermosetting layer alone. Specifically, the configuration, where the laser mark layer is a thermosetting layer and the adhesive layer is a thermoplastic layer in the adhesive sheet, is advantageous for allowing the adhesive sheet, when serving as a back surface protective film, to surely provide the visibility of the information marked by laser marking and, compatibly with this, to actually have satisfactory cleaving ability.

[0014]

The adhesive sheet has a ratio of the thickness of the laser mark layer to the thickness of the adhesive layer of preferably from 0.47 to 12, more preferably from 0.65 to 12, furthermore preferably from 0.75 to 7.5, and still more preferably from 0.85 to 5.5. Such configurations are preferred for allowing the adhesive sheet to combine properties required of a first surface with properties required of a second surface, where the first surface is defined by the laser mark layer, and the second surface is defined by the adhesive layer, is opposite to the first surface, and is a surface onto which the work is to be laminated (work-mount surface). Specifically, the configurations are preferred for allowing the laser mark layer to surely provide the visibility of the information marked by laser marking and, compatibly with this, for allowing the surface defined by the adhesive layer to offer adhesiveness to the work. The ratio is preferably high, from the viewpoint of restraining cracking when the dicing tape-combined adhesive sheet, as bearing the wafer on the adhesive sheet side, is used in the blade dicing step as above, where the cracking may occur in wafer cut sections, namely, chip sides due to impact and/or friction by the dicing blade during cutting. On the other hand, the ratio is preferably low, from the viewpoint of actually allowing

the adhesive sheet to be cleavable satisfactorily, when the dicing tape-combined adhesive sheet, as bearing the wafer on the adhesive sheet side, is used in the expanding step for cleaving.

Brief Description of Drawings

[0015]

FIG. 1 is a schematic cross-sectional view of a dicing tape-combined adhesive sheet according to one embodiment of the present invention;

FIGS. 2A and 2B illustrate a part of steps in a semiconductor device production method in which the dicing tape-combined adhesive sheet illustrated in FIG. 1 is used;

FIGS. 3A and 3B illustrate a part of steps in the semiconductor device production method in which the dicing tape-combined adhesive sheet illustrated in FIG. 1 is used;

FIG. 4 illustrates a part of steps in the semiconductor device production method in which the dicing tape-combined adhesive sheet illustrated in FIG. 1 is used;

FIG. 5 illustrates a part of steps in the semiconductor device production method in which the dicing tape-combined adhesive sheet illustrated in FIG. 1 is used;

FIG. 6 illustrates a part of steps in the semiconductor device production method in which the dicing tape-combined adhesive sheet illustrated in FIG. 1 is used;

FIGs. 7A, 7B, and 7C illustrate a part of steps in the semiconductor device production method in which the dicing tape-combined adhesive sheet illustrated in FIG. 1 is used;

FIGs. 8A and 8B illustrate a part of steps in the semiconductor device production method in which the dicing tape-combined adhesive sheet illustrated in FIG. 1 is used;

FIGs. 9A, 9B, and 9C illustrate a part of steps in the semiconductor device production method in which the dicing tape-combined adhesive sheet illustrated in FIG. 1 is used; and

FIGs. 10A and 10B illustrate a part of steps in the semiconductor device production method in which the dicing tape-combined adhesive sheet illustrated in FIG. 1 is used.

Description of Embodiments

[0016]

FIG. 1 is a schematic cross-sectional view of a dicing tape-combined adhesive sheet X according to one embodiment of the present invention. The dicing tape-combined adhesive sheet X is usable in a semiconductor device production process and has a multilayer structure including a film 10, which is an adhesive sheet, and a dicing tape 20. In the embodiment, the film 10 is a back surface protective film to be laminated onto a surface on which a circuit has not be formed, namely, onto a back surface (rear surface) of a work

such as a semiconductor wafer. The dicing tape 20 has a multilayer structure including a substrate 21 and a pressure-sensitive adhesive layer 22. The pressure-sensitive adhesive layer 22 has an adhesive face 22a which faces the film 10. The film 10 removably adheres to the pressure-sensitive adhesive layer 22 or to the adhesive face 22a of the layer 22. The dicing tape-combined adhesive sheet X has a disc shape having a size corresponding to the work such as a semiconductor wafer. Specifically, the dicing tape-combined adhesive sheet X as above is usable as a dicing tape-combined back surface protective film in a process of yielding semiconductor chips each bearing an adhesive film, where the adhesive film is provided for protecting the semiconductor chip back surface and has a size corresponding to the chip.

[0017]

The film 10, which serves as a back surface protective film, has a multilayer structure including a laser mark layer 11 and an adhesive layer 12. The laser mark layer 11 is positioned in the film 10 so as to face the dicing tape 20 and adheres to the dicing tape 20 or to the pressure-sensitive adhesive layer 22 of the dicing tape 20. In the laser mark layer 11, the surface facing the dicing tape 20 will undergo laser marking in a semiconductor device production process. In the embodiment, the laser mark layer

11 is a thermosetting layer containing a thermosetting (thermally curable) component and has been already thermally cured. The adhesive layer 12 is positioned in the film 10 at a side onto which the work such as a semiconductor wafer will be laminated. In the embodiment, the adhesive layer 12 is a thermoplastic adhesive layer.

[0018]

The laser mark layer 11 in the film 10 may have a formulation including, as resin components, a thermosetting resin and a thermoplastic resin in combination, or a formulation including a thermoplastic resin that contains a thermally curable functional group capable of reacting with a curing agent to form bonding (thermally curably functionalized thermoplastic resin).

[0019]

When the laser mark layer 11 has a formulation including a thermosetting resin and a thermoplastic resin in combination, non-limiting examples of the thermosetting resin include epoxy resins, phenolic resins, amino resins, unsaturated polyester resins, polyurethane resins, silicone resins, and thermosetting polyimide resins. The laser mark layer 11 may contain each of different thermosetting resins alone or in combination. The thermosetting resin(s) for use in the laser mark layer 11 of the film 10 is preferably selected from epoxy resins, because such epoxy resins tend

to have a low content of ionic impurities and other components that may cause corrosion of the semiconductor chips, where each of the semiconductor chips will be protected by a back surface protective film derived from the film 10 by an after-mentioned procedure. The curing agent to allow the epoxy resins to develop thermal curability is preferably selected from phenolic resins.

[0020]

Non-limiting examples of the epoxy resins include bifunctional epoxy resins and multifunctional epoxy resins, such as bisphenol-A epoxy resins, bisphenol-F epoxy resins, bisphenol-S epoxy resins, brominated bisphenol-A epoxy resins, hydrogenated bisphenol-A epoxy resins, bisphenol-AF epoxy resins, biphenyl epoxy resins, naphthalene epoxy resins, fluorene epoxy resins, epoxy phenol novolac resins, epoxy o-cresol novolac resins, trishydroxyphenylmethane epoxy resins, and tetraphenylolthane epoxy resins. Non-limiting examples of the epoxy resins also include hydantoin epoxy resins, tris-glycidyl isocyanurate epoxy resins, and glycidylamine epoxy resins. The laser mark layer 11 may contain each of different epoxy resins alone or in combination.

[0021]

The phenolic resins act as curing agents for epoxy resins. Non-limiting examples of such phenolic resins

include novolac phenolic resins such as phenol novolac resins, phenol aralkyl resins, cresol novolac resins, tert-butylphenol novolac resins, and nonylphenol novolac resins. Non-limiting examples of the phenolic resins also include resol resins; and polyoxystyrenes such as poly(p-oxystyrene)s. The phenolic resin for use in the laser mark layer 11 is particularly preferably selected from phenol novolac resins and phenol aralkyl resins. The laser mark layer 11 may contain each of different phenolic resins alone or in combination as a curing agent for epoxy resins.

[0022]

Assume that the laser mark layer 11 contains an epoxy resin, in combination with a phenolic resin as a curing agent for the epoxy resin. In this case, the two resins may be formulated so that the proportion of hydroxy groups in the phenolic resin is preferably 0.5 to 2.0 equivalents, and more preferably 0.8 to 1.2 equivalents, per equivalent of epoxy groups in the epoxy resin. Such configuration is preferred for allowing the curing reaction of the epoxy resin and the phenolic resin to proceed sufficiently in curing of the laser mark layer 11.

[0023]

The thermosetting resin, when contained in the laser mark layer 11, is present in a proportion of preferably 5 to 60 mass percent, and more preferably 10 to 50 mass percent,

from the viewpoint of curing the laser mark layer 11 appropriately.

[0024]

A thermoplastic resin in the laser mark layer 11 acts typically as a binder. When the laser mark layer 11 has a formulation including a thermosetting resin and a thermoplastic resin in combination, non-limiting examples of the thermoplastic resin include acrylic resins, natural rubber, isobutylene-isoprene rubber, isoprene rubber, chloroprene rubber, ethylene-vinyl acetate copolymers, ethylene-acrylic acid copolymers, ethylene-acrylic ester copolymers, polybutadiene resins, polycarbonate resins, thermoplastic polyimide resins, nylon-6 (polyamide-6), nylon-6,6 (polyamide-6,6), and other polyamide resins, phenoxy resins, poly(ethylene terephthalate)s, poly(butylene terephthalate)s, and other saturated polyester resins, polyamide-imide resins, and fluorocarbon resins. The laser mark layer 11 may contain each of different thermoplastic resins alone or in combination. The thermoplastic resin(s) for use in the laser mark layer 11 is preferably selected from acrylic resins because of having a small content of ionic impurities and having high heat resistance.

[0025]

When the laser mark layer 11 contains an acrylic resin as the thermoplastic resin, the acrylic resin preferably

includes a monomer unit derived from a (meth)acrylic ester in a largest mass proportion. As used herein, the term "(meth)acrylic" refers to "acrylic" and/or "methacrylic".

[0026]

Examples of the (meth)acrylic ester from which a monomer unit of the acrylic resin is derived, namely, examples of the (meth)acrylic ester as a constitutional monomer to constitute the acrylic resin include (meth)acrylic alkyl esters, (meth)acrylic cycloalkyl esters, and (meth)acrylic aryl esters. Non-limiting examples of the (meth)acrylic alkyl esters include, of (meth)acrylic acid, methyl ester, ethyl ester, propyl ester, isopropyl ester, butyl ester, isobutyl ester, s-butyl ester, t-butyl ester, pentyl ester, isopentyl ester, hexyl ester, heptyl ester, octyl ester, 2-ethylhexyl ester, isooctyl ester, nonyl ester, decyl ester, isodecyl ester, undecyl ester, dodecyl ester (namely, lauryl ester), tridecyl ester, tetradecyl ester, hexadecyl ester, octadecyl ester, and eicosyl ester. Non-limiting examples of the (meth)acrylic cycloalkyl esters include, of (meth)acrylic acid, cyclopentyl ester and cyclohexyl ester. Non-limiting examples of the (meth)acrylic aryl esters include phenyl (meth)acrylate and benzyl (meth)acrylate. The acrylic resin may be derived from a constitutional monomer or monomers including each of different (meth)acrylic esters alone or in combination. The

acrylic resin can result from polymerization of a material monomer or monomers for acrylic resin formation. Non-limiting examples of the polymerization technique include solution polymerization, emulsion polymerization, bulk polymerization, and suspension polymerization.

[0027]

The acrylic resin may be derived from constitutional monomers further including one or more types of other monomers that are copolymerizable with the (meth)acrylic ester, typically for modification of cohesive force and/or heat resistance of the resulting acrylic resin. Examples of such other monomers include, but are not limited to, carboxy-containing monomers, acid anhydride monomers, hydroxy-containing monomers, epoxy-containing monomers, sulfonate-containing monomers, phosphate-containing monomers, acrylamide, and acrylonitrile. Non-limiting examples of the carboxy-containing monomers include acrylic acid, methacrylic acid, carboxyethyl (meth)acrylate, carboxypentyl (meth)acrylate, itaconic acid, maleic acid, fumaric acid, and crotonic acid. Non-limiting examples of the acid anhydride monomers include maleic anhydride and itaconic anhydride. Non-limiting examples of the hydroxy-containing monomers include 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. Non-limiting examples of the epoxy-containing monomers include glycidyl (meth)acrylate and methylglycidyl (meth)acrylate. Non-limiting examples of the sulfonate-containing monomers include styrenesulfonic acid, allylsulfonic acid, 2-(meth)acrylamido-2-methylpropanesulfonic acid, (meth)acrylamidopropanesulfonic acid, and (meth)acryloyloxynaphthalenesulfonic acid. A non-limiting example of the phosphate-containing monomers is 2-hydroxyethylacryloyl phosphate.

[0028]

The acrylic resin, when contained in the laser mark layer 11, is preferably a copolymer derived from monomers selected as appropriate from butyl acrylate, ethyl acrylate, acrylonitrile, acrylic acid, 2-ethylhexyl acrylate, and glycidyl acrylate. This is preferred for allowing the laser mark layer 11 to surely have satisfactory laser markability.

[0029]

When the laser mark layer 11 has a formulation including a thermally curably functionalized thermoplastic resin, the thermoplastic resin for use herein may be, for example, an acrylic resin containing a functional group that gives thermal curability (thermally curably functionalized

acrylic resin). An acrylic resin to constitute the thermally curably functionalized acrylic resin preferably includes a monomer unit derived from a (meth)acrylic ester in a largest mass proportion. Non-limiting examples of such (meth)acrylic ester include (meth)acrylic esters as with those exemplified above as constitutional monomers for the acrylic resin contained in the laser mark layer 11. The acrylic resin to constitute the thermally curably functionalized acrylic resin may include a monomer unit or units derived from one or more types of other monomers that are copolymerizable with the (meth)acrylic ester, typically for the modification of cohesive force and/or heat resistance of the acrylic resin. Non-limiting examples of such monomers for use herein include the monomers described as other monomers that are copolymerizable with the (meth)acrylic ester to constitute the acrylic resin for use in the laser mark layer 11. Non-limiting examples of the thermally curable functional group to constitute the thermally curably functionalized acrylic resin include glycidyl, carboxy, hydroxy, and isocyanato. Among them, glycidyl and carboxy are advantageously usable. Specifically, the thermally curably functionalized acrylic resin is advantageously selected from glycidyl-containing acrylic resins and carboxy-containing acrylic resins. According to the type of the thermally curable functional

group in the thermally curably functionalized acrylic resin, a curing agent that is reactive with the functional group may be selected. When the thermally curably functionalized acrylic resin contains glycidyl as the thermally curable functional group, the curing agent for use herein can be selected from phenolic resins as with those exemplified above as the curing agent for epoxy resins.

[0030]

A composition to form the laser mark layer 11 preferably contains a thermosetting catalyst. The incorporation of such thermosetting catalyst into the laser mark layer-forming composition is preferred for allowing the curing reaction of a resin component to proceed sufficiently and/or to proceed at a higher reaction rate in curing of the laser mark layer 11. Examples of the thermosetting catalyst include, but are not limited to, imidazole compounds, triphenylphosphine compounds, amine compounds, and trihaloborane compounds. Non-limiting examples of the imidazole compounds include 2-methylimidazole, 2-undecylimidazole, 2-heptadecylimidazole, 1,2-dimethylimidazole, 2-ethyl-4-methylimidazole, 2-phenylimidazole, 2-phenyl-4-methylimidazole, 1-benzyl-2-methylimidazole, 1-benzyl-2-phenylimidazole, 1-cyanoethyl-2-methylimidazole, 1-cyanoethyl-2-undecylimidazole, 1-cyanoethyl-2-phenylimidazolium trimellitate, 2,4-diamino-6-

[2'-methylimidazolyl-(1')]-ethyl-s-triazine, 2,4-diamino-6-[2'-undecylimidazolyl-(1')]-ethyl-s-triazine, 2,4-diamino-6-[2'-ethyl-4'-methylimidazolyl-(1')]-ethyl-s-triazine, 2,4-diamino-6-[2'-methylimidazolyl-(1')]-ethyl-s-triazine isocyanuric acid adduct, 2-phenyl-4,5-dihydroxymethylimidazole, and 2-phenyl-4-methyl-5-hydroxymethylimidazole. Non-limiting examples of the triphenylphosphine compounds include triphenylphosphine, tri(butylphenyl)phosphine, tri(p-methylphenyl)phosphine, tri(nonylphenyl)phosphine, diphenyltolylphosphine, tetraphenylphosphonium bromide, methyltriphenylphosphonium bromide, methyltriphenylphosphonium chloride, methoxymethyltriphenylphosphonium chloride, and benzyltriphenylphosphonium chloride. The category "triphenylphosphine compounds" herein also includes compounds having both a triphenylphosphine structure and a triphenylborane structure. Non-limiting examples of such compounds include tetraphenylphosphonium tetraphenylborate, tetraphenylphosphonium tetra-p-tolylborate, benzyltriphenylphosphonium tetraphenylborate, and triphenylphosphine triphenylborane. Non-limiting examples of the amine compounds include monoethanolamine trifluoroborate and dicyandiamide. A non-limiting example of the trihaloborane compounds is trichloroborane. The laser mark layer-forming composition may contain each of

different thermosetting catalysts alone or in combination.

[0031]

The laser mark layer 11 may contain a filler. The incorporation of such filler into the laser mark layer 11 is preferred so as to adjust the properties of the laser mark layer 11, such as elastic modulus, yield strength, and breaking elongation. The category "filler" includes inorganic fillers and organic fillers. Non-limiting examples of constitutional materials of the inorganic fillers include aluminum hydroxide, magnesium hydroxide, calcium carbonate, magnesium carbonate, calcium silicate, magnesium silicate, calcium oxide, magnesium oxide, aluminum oxide, aluminum nitride, aluminum borate whiskers, boron nitride, crystalline silica, and amorphous silica. Non-limiting examples of the constitutional materials of the inorganic fillers also include elemental metals such as aluminum, gold, silver, copper, and nickel; alloys; amorphous carbon; and graphite. Non-limiting examples of constitutional materials of the organic fillers include poly(methyl methacrylate)s (PMMA's), polyimides, polyamide-imides, poly(ether ether ketone)s, polyetherimides, and polyesterimides. The laser mark layer 11 may contain each of different fillers alone or in combination. The filler may have any shape such as spherical, acicular, or flaky shape. The filler, when contained in the laser mark layer

11, has an average particle size of preferably 0.03 to 5 μm , more preferably 0.04 to 3 μm , and furthermore preferably 0.05 to 1 μm . Namely, the laser mark layer 11 preferably contains a nanofiller. The configuration where the laser mark layer 11 contains, as a filler, a nanofiller having a particle size within the range is advantageous for the film 10, which is to be cut into pieces, to be partible and cleavable surely satisfactorily. The average particle size of the filler can be determined typically using a laser diffraction particle size analyzer LA-910 (trade name, supplied by HORIBA, Ltd.). The content of the filler, when contained in the laser mark layer 11, is preferably 10 mass percent or more, more preferably 15 mass percent or more, and furthermore preferably 20 mass percent or more. The content is preferably 50 mass percent or less, more preferably 45 mass percent or less, and furthermore preferably 43 mass percent or less.

[0032]

In the embodiment, the laser mark layer 11 contains a colorant. The colorant may be any of pigments and dyes. Non-limiting examples of the colorant include black colorants, cyan colorants, magenta colorants, and yellow colorants. The laser mark layer 11 preferably contains a black colorant, so as to actually provide high visibility of information, which will be marked on the laser mark layer 11

by laser marking. Non-limiting examples of the black colorants include carbon black, graphite, copper oxide, manganese dioxide, azo pigments (such as azomethine-azo black), aniline black, perylene black, black titanium oxide, cyanine black, activated carbon, ferrite, magnetite, chromium oxide, iron oxide, molybdenum disulfide, composite oxide black coloring agents, anthraquinone organic black dyes, and azo organic black dyes. Non-limiting examples of the carbon black include furnace black, channel black, acetylene black, thermal black, and lampblack. Non-limiting examples of the black colorants also include C.I. Solvent Black 3, 7, 22, 27, 29, 34, 43, and 70; C.I. Direct Black 17, 19, 22, 32, 38, 51, and 71; C.I. Acid Black 1, 2, 24, 26, 31, 48, 52, 107, 109, 110, 119, and 154; C.I. Disperse Black 1, 3, 10, and 24; and C.I. Pigment Black 1 and 7. The laser mark layer 11 may contain each of different colorants alone or in combination. The content of the colorant in the laser mark layer 11 is preferably 0.5 weight percent or more, more preferably 1 weight percent or more, and furthermore preferably 2 weight percent or more; and is preferably 10 weight percent or less, more preferably 8 weight percent or less, and furthermore preferably 6 weight percent or less. These configurations relative to the colorant content are preferred for actually providing high visibility of information, which will be marked on the laser

mark layer 11 by laser marking.

[0033]

The laser mark layer 11 may contain one or more types of other components, as needed. Examples of the other components include, but are not limited to, flame retardants, silane coupling agents, and ion trapping agents (ion scavengers). Non-limiting examples of the flame retardants include antimony trioxide, antimony pentoxide, and brominated epoxy resins. Non-limiting examples of the silane coupling agents include β -(3,4-epoxycyclohexyl)ethyltrimethoxysilane, γ -glycidoxypropyltrimethoxysilane, and γ -glycidoxypropylmethyldiethoxysilane. Non-limiting examples of the ion trapping agents include hydrotalcites, bismuth hydroxide, hydrous antimony oxides (such as IXE-300, supplied by Toagosei Co. Ltd.), zirconium phosphates having a specific structure (such as IXE-100, supplied by Toagosei Co. Ltd.), magnesium silicates (such as KYOWAAD 600, supplied by Kyowa Chemical Industry Co., Ltd.), and aluminum silicates (such as KYOWAAD 700, supplied by Kyowa Chemical Industry Co., Ltd.). In addition, examples of the ion trapping agents usable herein also include compounds capable of forming a complex with a metal ion. Non-limiting examples of such compounds include triazole compounds, tetrazole compounds, and bipyridyl compounds. Among them,

triazole compounds are preferred from the viewpoint of stability of the complex formed with the metal ion. Non-limiting examples of such triazole compounds include 1,2,3-benzotriazole, 1-{N,N-bis(2-ethylhexyl)aminomethyl}benzotriazole, carboxybenzotriazole, 2-(2-hydroxy-5-methylphenyl)benzotriazole, 2-(2-hydroxy-3,5-di-t-butylphenyl)-5-chlorobenzotriazole, 2-(2-hydroxy-3-t-butyl-5-methylphenyl)-5-chlorobenzotriazole, 2-(2-hydroxy-3,5-di-t-amylphenyl)benzotriazole, 2-(2-hydroxy-5-t-octylphenyl)benzotriazole, 6-(2-benzotriazolyl)-4-t-octyl-6'-t-butyl-4'-methyl-2,2'-methylenebisphenol, 1-(2,3-dihydroxypropyl)benzotriazole, 1-(1,2-dicarboxydiethyl)benzotriazole, 1-(2-ethylhexylaminomethyl)benzotriazole, 2,4-di-t-pentyl-6-{(H-benzotriazol-1-yl)methyl}phenol, 2-(2-hydroxy-5-t-butylphenyl)-2H-benzotriazole, octyl 3-[3-t-butyl-4-hydroxy-5-(5-chloro-2H-benzotriazol-2-yl)phenyl]propionate, 2-ethylhexyl 3-[3-t-butyl-4-hydroxy-5-(5-chloro-2H-benzotriazol-2-yl)phenyl]propionate, 2-(2H-benzotriazol-2-yl)-6-(1-methyl-1-phenylethyl)-4-(1,1,3,3-tetramethylbutyl)phenol, 2-(2H-benzotriazol-2-yl)-4-t-butylphenol, 2-(2-hydroxy-5-methylphenyl)benzotriazole, 2-(2-hydroxy-5-t-octylphenyl)-benzotriazole, 2-(3-t-butyl-2-hydroxy-5-methylphenyl)-5-chlorobenzotriazole, 2-(2-hydroxy-3,5-di-t-amylphenyl)benzotriazole, 2-(2-hydroxy-3,5-di-t-

butylphenyl)-5-chlorobenzotriazole, 2-[2-hydroxy-3,5-di(1,1-dimethylbenzyl)phenyl]-2H-benzotriazole, 2,2'-methylenebis[6-(2H-benzotriazol-2-yl)-4-(1,1,3,3-tetramethylbutyl)phenol], 2-[2-hydroxy-3,5-bis(α,α -dimethylbenzyl)phenyl]-2H-benzotriazole, and methyl 3-[3-(2H-benzotriazol-2-yl)-5-t-butyl-4-hydroxyphenyl]propionate. Non-limiting examples of the ion trapping agents for use herein also include certain hydroxy-containing compounds such as quinol compounds, hydroxyanthraquinone compounds, and polyphenol compounds. Specifically, non-limiting examples of such hydroxy-containing compounds include 1,2-benzenediol, alizarin, anthrarufin, tannin, gallic acid, methyl gallate, and pyrogallol.

[0034]

The adhesive layer 12 in the film 10 may have a formulation including, as resin components, both a thermosetting resin and a thermoplastic resin, or may have a formulation including, as a resin component, a thermoplastic resin containing a thermally curable functional group that can react with a curing agent to form bonding.

[0035]

When the adhesive layer 12 has a formulation including a thermosetting resin and a thermoplastic resin in combination, non-limiting examples of the thermosetting resin include epoxy resins, phenolic resins, amino resins,

unsaturated polyester resins, polyurethane resins, silicone resins, and thermosetting polyimide resins. The adhesive layer 12 may contain each of different thermosetting resins alone or in combination. The thermosetting resin for use in the adhesive layer 12 of the film 10 is preferably selected from epoxy resins, because such epoxy resins tend to have a low content of ionic impurities and other substances that may cause corrosion of a semiconductor chip, which is to be protected by a back surface protective film, where the back surface protective film will be derived from the film 10 by a procedure mentioned later.

[0036]

Non-limiting examples of the epoxy resin or resins for use in the adhesive layer 12 are as with those exemplified above as epoxy resins that are usable as a thermosetting resin when the laser mark layer 11 has a formulation including the thermosetting resin and a thermoplastic resin in combination. The epoxy resin for use in the adhesive layer 12 is preferably selected from epoxy phenol novolac resins, epoxy o-cresol novolac resins, biphenyl epoxy resins, trishydroxyphenylmethane epoxy resins, and tetraphenylolthane epoxy resins, because these epoxy resins have excellent heat resistance and are highly reactive with a phenolic resin, which serves as a curing agent.

[0037]

Non-limiting examples of the phenolic resin that can act as a curing agent for epoxy resins in the adhesive layer 12 include those exemplified above as the phenolic resin as a curing agent for epoxys resin in the laser mark layer 11. The adhesive layer 12 may contain each of different phenolic resins alone or in combination as a curing agent for epoxy resins.

[0038]

When the adhesive layer 12 contains an epoxy resin in combination with a phenolic resin as a curing agent for the epoxy resin, the two resins are blended so that the proportion of hydroxy groups in the phenolic resin is preferably 0.5 to 2.0 equivalents, and more preferably 0.8 to 1.2 equivalents, per equivalent of epoxy groups in the epoxy resin.

[0039]

The adhesive layer 12 may contain the thermosetting resin in a content of preferably 5 to 70 mass percent, and more preferably 10 to 60 mass percent, from the viewpoint of surely offering adhesiveness to the work such as a semiconductor wafer.

[0040]

A thermoplastic resin in the adhesive layer 12 acts typically as a binder. When the adhesive layer 12 has a formulation including a thermosetting resin and a

thermoplastic resin in combination, non-limiting examples of the thermoplastic resin include those exemplified above as the thermoplastic resin for use when the laser mark layer 11 has a formulation including a thermosetting resin and the thermoplastic resin in combination. The adhesive layer 12 may contain each of different thermoplastic resins alone or in combination. The thermoplastic resin for use in the adhesive layer 12 is preferably selected from acrylic resins, because such acrylic resins have a low content of ionic impurities and have high heat resistance.

[0041]

When the adhesive layer 12 contains an acrylic resin as the thermoplastic resin, the acrylic resin preferably includes a monomer unit derived from a (meth)acrylic ester in a largest mass proportion. The (meth)acrylic ester to constitute the monomer unit of the acrylic resin may be selected typically from the (meth)acrylic esters mentioned above as the constitutional monomer to form an acrylic resin for use when the laser mark layer 11 contains the acrylic resin as a thermoplastic resin. The acrylic resin in the adhesive layer 12 may be derived from a constitutional monomer or monomers including each of different (meth)acrylic esters alone or in combination. The acrylic resin may be derived from constitutional monomers further including one or more types of other monomers that are

copolymerizable with the (meth)acrylic ester, typically for the modification of cohesive force and/or heat resistance of the acrylic resin. Non-limiting examples of such monomers for use herein include those exemplified above as the other monomers that are copolymerizable with the (meth)acrylic ester to constitute the acrylic resin for use in the laser mark layer 11.

[0042]

The acrylic resin, when contained in the adhesive layer 12, is preferably a copolymer derived from monomers selected as appropriate from butyl acrylate, ethyl acrylate, acrylonitrile, acrylic acid, 2-ethylhexyl acrylate, and glycidyl acrylate. This is preferred from the viewpoint of allowing the adhesive layer 12 to surely have adhesiveness to the work such as a semiconductor wafer.

[0043]

When the adhesive layer 12 has a formulation including a thermally curably functionalized thermoplastic resin, the thermoplastic resin for use herein may be a thermally curably functionalized acrylic resin. The acrylic resin to constitute the thermally curably functionalized acrylic resin preferably includes a monomer unit derived from a (meth)acrylic ester in a largest mass proportion. Such (meth)acrylic ester for use herein may be selected typically from (meth)acrylic esters as with those exemplified above as

the constitutional monomers to constitute the acrylic resin contained in the laser mark layer 11. The acrylic resin to constitute the thermally curably functionalized acrylic resin may be derived from monomer units further including one or more types of other monomers that are copolymerizable with the (meth)acrylic ester, typically for the modification of cohesive force and/or heat resistance of the acrylic resin. Non-limiting examples of such monomers for use herein include those exemplified above as the other monomers that are copolymerizable with the (meth)acrylic ester to constitute the acrylic resin for use in the laser mark layer 11. Non-limiting examples of the thermally curable functional group to constitute the thermally curably functionalized acrylic resin include glycidyl, carboxy, hydroxy, and isocyanato. Among them, glycidyl and carboxy are advantageously usable. According to the type of the thermally curable functional group in the thermally curably functionalized acrylic resin, a curing agent that is reactive with the thermally curable functional group may be selected. When the thermally curably functionalized acrylic resin contains glycidyl as the thermally curable functional group, the curing agent for use herein can be selected from phenolic resins as with those exemplified above as the curing agent for epoxy resins.

[0044]

A composition to form the adhesive layer 12 is preferably devoid of thermosetting catalysts. When the composition to form the adhesive layer 12 contains a thermosetting catalyst, the thermosetting catalyst for use herein may be selected typically from those exemplified above as the thermosetting catalysts that can be incorporated into the laser mark layer-forming composition. [0045]

The adhesive layer 12 may contain a filler. The incorporation of a filler into the adhesive layer 12 is preferred so as to adjust properties of the adhesive layer 12, such as elastic modulus, yield strength, and breaking elongation. Non-limiting examples of the filler for use in the adhesive layer 12 include those exemplified above as the filler for use in the laser mark layer 11. The adhesive layer 12 may contain each of different fillers alone or in combination. The filler may have any shape such as spherical, acicular, or flaky shape. The filler, when contained in the adhesive layer 12, has an average particle size of preferably 0.03 to 5 μm , more preferably 0.04 to 3 μm , and furthermore preferably 0.05 to 1 μm . Namely, the adhesive layer 12 preferably contains a nanofiller. The configuration in which the adhesive layer 12 contains, as a filler, a nanofiller having a particle size within the range, is advantageous for avoiding or restraining damage,

due to the filler in the adhesive layer 12, of the work to be applied or mounted onto the film 10. The configuration is also advantageous for surely allowing the film 10, which will be divided into pieces, to be partible and cleavable satisfactorily. The content of the filler, when contained in the adhesive layer 12, is preferably 10 mass percent or more, more preferably 15 mass percent or more, and furthermore preferably 20 mass percent or more. The content is preferably 50 mass percent or less, more preferably 45 mass percent or less, and furthermore preferably 43 mass percent or less.

[0046]

The adhesive layer 12 may contain a colorant. Non-limiting examples of the colorant for use in the adhesive layer 12 include those exemplified above as the colorant for use in the laser mark layer 11. The adhesive layer 12 preferably contains a black colorant. This is preferred for surely providing high contrast between a portion marked by laser marking and another portion on the laser mark layer 11 in the film 10, and for thereby actually providing high visibility of the marked information. The adhesive layer 12 may contain each of different colorants alone or in combination. The content of the colorant, when contained in the adhesive layer 12, is preferably 0.5 weight percent or more, more preferably 1 weight percent or more, and

furthermore preferably 2 weight percent or more. The content is preferably 10 weight percent or less, more preferably 8 weight percent or less, and furthermore preferably 6 weight percent or less. These configurations relating to the colorant content are preferred for actually providing the high visibility of the information marked by laser marking.

[0047]

The adhesive layer 12 may contain, as needed, one or more types of other components. Non-limiting examples of the other components include the flame retardants, silane coupling agents, and ion scavengers, as specifically described above relating to the laser mark layer 11.

[0048]

The film 10, which has a multilayer structure including the laser mark layer 11 and the adhesive layer 12, has a thickness of preferably 8 μm or more, and more preferably 10 μm or more, and of preferably 30 μm or less, and more preferably 25 μm or less. The ratio of the thickness of the laser mark layer 11 to the thickness of the adhesive layer 12 is preferably from 0.47 to 12, more preferably from 0.65 to 12, furthermore preferably from 0.75 to 7.5, and still more preferably from 0.85 to 5.5.

[0049]

The substrate 21 of the dicing tape 20 in the dicing

tape-combined adhesive sheet X is a constituent that acts as a support (backing) in the dicing tape 20 or in the dicing tape-combined adhesive sheet X. The substrate 21 is typically a plastic substrate. The plastic substrate for use herein is advantageously a plastic film. Examples of a constitutional material for the plastic substrate include, but are not limited to, polyolefins, polyesters, polyurethanes, polycarbonates, poly(ether ether ketone)s, polyimides, polyetherimides, polyamides, wholly aromatic polyamides, poly(vinyl chloride)s, poly(vinylidene chloride)s, polyphenylsulfides, aramids, fluorocarbon resins, cellulosic resins, and silicone resins. Non-limiting examples of the polyolefins include low-density polyethylenes, linear low-density polyethylenes, medium-density polyethylenes, high-density polyethylenes, ultralow-density polyethylenes, propylene random copolymers, propylene block copolymers, homopolypropylenes, polybutenes, polymethylpentenes, ethylene-vinyl acetate copolymers, ionomer resins, ethylene-(meth)acrylic acid copolymers, ethylene-(meth)acrylic ester copolymers, ethylene-butene copolymers, and ethylene-hexene copolymers. Non-limiting examples of the polyesters include poly(ethylene terephthalate)s, poly(ethylene naphthalate)s, and poly(butylene terephthalate)s. The substrate 21 may be made from each of different materials alone or in combination.

The substrate 21 may have a single-layer structure or a multilayer structure. When the pressure-sensitive adhesive layer 22 on or over the substrate 21 is curable with ultraviolet radiation as described later, the substrate 21 preferably has permeability to the ultraviolet radiation. The substrate 21, when made of a plastic film, may be a non-oriented film, or a uniaxially oriented film, or a biaxially oriented film. In the embodiment, the substrate 21 is preferably a poly(vinyl chloride) substrate or an ethylene-vinyl acetate copolymer substrate.

[0050]

Assume that the dicing tape 20 or the substrate 21 is to be shrunk typically by partial heating upon use of the dicing tape-combined adhesive sheet X. In this case, the substrate 21 preferably has heat shrinkability. The substrate 21, when being made of a plastic film, is preferably a biaxially oriented film, so as to actually allow the dicing tape 20 or the substrate 21 to have isotropic thermal shrinkability. The dicing tape 20 or the substrate 21 has a thermal shrinkage rate of preferably 2% to 30%, more preferably 2% to 25%, furthermore preferably 3% to 20%, and still more preferably 5% to 20%, where the thermal shrinkage rate is determined by a heat treatment test performed as heating at a temperature of 100°C for 60 seconds. As used herein, the term "thermal shrinkage rate"

refers to at least one of the thermal shrinkage rate in a so-called machine direction (MD) and the thermal shrinkage rate in a so-called transverse direction (TD).

[0051]

In the substrate 21, the surface facing the pressure-sensitive adhesive layer 22 may have undergone any of physical treatments, chemical treatments, and primer coating, so as to have higher adhesion to the pressure-sensitive adhesive layer 22. Non-limiting examples of the physical treatments include corona treatment, plasma treatment, sand mat treatment, exposure treatment to ozone, exposure treatment to flame, exposure treatment to a high-voltage electric shock, and treatment with ionizing radiation. A non-limiting example of the chemical treatments is chromate treatment.

[0052]

The substrate 21 has a thickness of preferably 40 μm or more, more preferably 50 μm or more, and furthermore preferably 60 μm or more, so as to surely have such strength that the substrate 21 can act as a support in the dicing tape 20 or in the dicing tape-combined adhesive sheet X. The substrate 21 has a thickness of preferably 200 μm or less, more preferably 180 μm or less, and furthermore preferably 150 μm or less, from the viewpoint of actually providing appropriate flexibility in the dicing tape 20 or

in the dicing tape-combined adhesive sheet X.

[0053]

The pressure-sensitive adhesive layer 22 of the dicing tape 20 contains a radiation-curable pressure-sensitive adhesive and has curability with radiation, where the radiation-curable pressure-sensitive adhesive is a pressure-sensitive adhesive which is curable by irradiation with radiation in a use process of the dicing tape-combined adhesive sheet X. The pressure-sensitive adhesive layer 22 in the embodiment may include each of different radiation-curable pressure-sensitive adhesives alone or in combination. The pressure-sensitive adhesive layer 22 may be, entirely or partially, made from (formed from) a radiation-curable pressure-sensitive adhesive. For example, assume that the pressure-sensitive adhesive layer 22 has a single-layer structure. In this case, it is acceptable that the whole of the pressure-sensitive adhesive layer 22 is made of a radiation-curable pressure-sensitive adhesive; or that a predetermined portion in the pressure-sensitive adhesive layer 22 is made of a radiation-curable pressure-sensitive adhesive, and another portion is made from a material other than such a radiation-curable pressure-sensitive adhesive. A non-limiting example of the predetermined portion is a central region onto which the work is to be applied; and a non-limiting example of the

other portion is a region onto which a ring frame is to be applied and which lies lateral to the central region.

Assume that the pressure-sensitive adhesive layer 22 has a multilayer structure. In this case, it is acceptable that all layers constituting the multilayer structure are made of a radiation-curable pressure-sensitive adhesive or adhesives; or that at least part, including a surface layer facing the film 10, of layers constituting the multilayer structure is made of a radiation-curable pressure-sensitive adhesive or adhesives.

[0054]

Non-limiting examples of the radiation-curable pressure-sensitive adhesive to constitute the pressure-sensitive adhesive layer 22 include pressure-sensitive adhesives that are curable by irradiation with electron beams, ultraviolet radiation (ultraviolet rays), alpha rays, beta rays, gamma rays, or X rays. In particular, ultraviolet-curable pressure-sensitive adhesives, which are pressure-sensitive adhesives curable by ultraviolet irradiation, are advantageously usable.

[0055]

Non-limiting examples of the radiation-curable pressure-sensitive adhesive to constitute the pressure-sensitive adhesive layer 22 include compounded radiation-curable pressure-sensitive adhesives each containing a base

polymer such as an acrylic polymer, which is as an acrylic pressure-sensitive adhesive, in combination with a radiation-polymerizable monomer component and/or oligomer component each containing a radiation-polymerizable carbon-carbon double bond or another radiation-polymerizable functional group.

[0056]

The acrylic polymer preferably includes a monomer unit derived from a (meth)acrylic ester in a largest mass proportion. Examples of the (meth)acrylic ester from which the monomer unit of the acrylic polymer is derived, namely, examples of the (meth)acrylic ester serving as a constitutional monomer to constitute the acrylic polymer include (meth)acrylic alkyl esters, (meth)acrylic cycloalkyl esters, and (meth)acrylic aryl esters. More specifically, non-limiting examples of the (meth)acrylic esters include (meth)acrylic esters as with those exemplified above relating to the acrylic resin for use in the laser mark layer 11 of the film 10. The acrylic polymer may be derived from a constitutional monomer or monomers including each of different (meth)acrylic esters alone or in combination. The constitutional monomer to constitute the acrylic polymer is preferably selected from 2-ethylhexyl acrylate and lauryl acrylate. The (meth)acrylic ester may be present in a proportion of preferably 40 mass percent or more, and more

preferably 60 mass percent or more, of the totality of constitutional monomers to constitute the acrylic polymer, so as to allow the (meth)acrylic ester to appropriately offer basic properties, such as tackiness, in the pressure-sensitive adhesive layer 22.

[0057]

The acrylic polymer may further include a monomer unit or units derived from one or more types of other monomers that are copolymerizable with the (meth)acrylic ester, typically for the modification of cohesive force and/or heat resistance of the acrylic polymer. Examples of such other monomers include carboxy-containing monomers, acid anhydride monomers, hydroxy-containing monomers, epoxy-containing monomers, sulfonate-containing monomers, phosphate-containing monomers, acrylamide, and acrylonitrile; and more specific, but non-limiting examples thereof include those exemplified above as other monomers copolymerizable with the (meth)acrylic ester to constitute the acrylic resin for use in the laser mark layer 11 of the film 10.

[0058]

The acrylic polymer, so as to form a cross-linked structure in its polymer skeleton, may include a monomer unit derived from a multifunctional monomer that is copolymerizable with the monomer component such as a (meth)acrylic ester. Non-limiting examples of such

multifunctional 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, polyglycidyl (meth)acrylates, polyester (meth)acrylates, and urethane (meth)acrylates. As used herein, the term "(meth)acrylate" refers to "acrylate" and/or "methacrylate". The acrylic polymer may be derived from constitutional monomers including each of different multifunctional monomers alone or in combination. The proportion of the multifunctional monomer is preferably 40 mass percent or less, and more preferably 30 mass percent or less, of the totality of constitutional monomers to constitute the acrylic polymer, so as to allow the (meth)acrylic ester to appropriately offer basic properties, such as tackiness, in the pressure-sensitive adhesive layer 22.

[0059]

The acrylic polymer can result from polymerization of a material monomer or monomers for the formation of the polymer. Non-limiting examples of the polymerization technique include solution polymerization, emulsion polymerization, bulk polymerization, and suspension polymerization. The pressure-sensitive adhesive layer 22 in

the dicing tape 20 or in the dicing tape-combined adhesive sheet X preferably has a smaller content of low-molecular-weight substances, from the viewpoint of providing high cleanliness in a semiconductor device production method in which the dicing tape 20 or the dicing tape-combined adhesive sheet X is used. Accordingly, the acrylic polymer has a number average molecular weight of preferably 10×10^4 or more, and more preferably 20×10^4 to 300×10^4 .

[0060]

The pressure-sensitive adhesive layer 22, or the pressure-sensitive adhesive to constitute the layer 22, may contain an external crosslinker or another material so as to allow the base polymer such as an acrylic polymer to have a higher number average molecular weight. Non-limiting examples of the external crosslinker, which reacts with the base polymer such as an acrylic polymer to form a cross-linked structure, include polyisocyanate compounds, epoxy compounds, polyol compounds, aziridine compounds, and melamine crosslinkers. The amount of the external crosslinker in the pressure-sensitive adhesive layer 22, or in the pressure-sensitive adhesive to constitute the layer 22, is preferably 5 parts by mass or less, and more preferably 0.1 to 5 parts by mass, per 100 parts by weight of the base polymer.

[0061]

Non-limiting examples of the radiation-polymerizable monomer component to constitute the radiation-curable pressure-sensitive adhesive include urethane (meth)acrylates, trimethylolpropane tri(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. Non-limiting examples of the radiation-polymerizable oligomer component to constitute the radiation-curable pressure-sensitive adhesive include oligomers such as oligourethanes, oligoethers, oligoesters, oligocarbonates, and oligobutadienes. Among them, those having a molecular weight of about 100 to about 30000 are appropriate. The total amount of the radiation-polymerizable monomer component and oligomer component in the radiation-curable pressure-sensitive adhesive may be determined within such a range as to appropriately lower the adhesive strength of the resulting pressure-sensitive adhesive layer 22, and is preferably 5 to 500 parts by mass, and more preferably 40 to 150 parts by mass, per 100 parts by weight of the base polymer such as an acrylic polymer. The compounded radiation-curable pressure-sensitive adhesive for use herein may also be selected typically from those disclosed in JP-A No. S60-196956.

[0062]

The radiation-curable pressure-sensitive adhesive to form the pressure-sensitive adhesive layer 22 may also be selected from endogenously-curable, radiation-curable pressure-sensitive adhesives each of which contains a base polymer containing a radiation-polymerizable carbon-carbon double bond or another radiation-polymerizable functional group in any of a polymer side chain, a polymer principal chain, and a terminal of the polymer principal chain. Such endogenously-curable, radiation-curable pressure-sensitive adhesives are advantageous for restraining unintended changes in adhesive properties with time, where the changes are due to migration of low molecular weight components in the resulting pressure-sensitive adhesive layer 22.

[0063]

The endogenously-curable, radiation-curable pressure-sensitive adhesive preferably contains a base polymer that includes an acrylic polymer as a basic skeleton. The acrylic polymer to constitute such basic skeleton may be selected from the above-mentioned acrylic polymers. The radiation-polymerizable carbon-carbon double bond may be introduced into the acrylic polymer typically by a technique as follows. Specifically, material monomers including a monomer containing a predetermined functional group (first functional group) are copolymerized to give an acrylic

polymer, and the acrylic polymer is subjected to a condensation reaction or addition reaction with a compound containing a predetermined second functional group and a radiation-polymerizable carbon-carbon double bond, while maintaining the radiation-polymerizability of the carbon-carbon double bond, where the second functional group is a functional group that is capable of reacting with and bonding to the first functional group.

[0064]

Non-limiting examples of the combination of the first functional group with the second functional group include the combinations of: carboxy with epoxy; epoxy with carboxy; carboxy with aziridyl; aziridyl with carboxy; hydroxy with isocyanato; and isocyanato with hydroxy. Among these combinations, the combination of hydroxy with isocyanato, and the combination of isocyanato with hydroxy are preferred for easy tracking of the reaction. It is more preferred that the first functional group contained in the acrylic polymer is hydroxy, and the second functional group is isocyanato, because, due to high reactivity of isocyanato, it is highly technically difficult to prepare an isocyanato-containing polymer. This configuration is preferred from the viewpoint of easiness in preparation, or availability, of the acrylic polymer. In this case, non-limiting examples of a compound containing a radiation-

polymerizable carbon-carbon double bond in combination with isocyanato as the second functional group, namely, non-limiting examples of an isocyanate compound containing a radiation-polymerizable unsaturated functional group include methacryloyl isocyanate, 2-methacryloyloxyethyl isocyanate (MOI), and m-isopropenyl- α,α -dimethylbenzyl isocyanate.

[0065]

The radiation-curable pressure-sensitive adhesive for the pressure-sensitive adhesive layer 22 preferably contains a photoinitiator. Examples of the photoinitiator include, but are not limited to, α -ketol compounds, acetophenone compounds, benzoin ether compounds, ketal compounds, aromatic sulfonyl chloride compounds, photoactive oxime compounds, benzophenone compounds, thioxanthone compounds, camphorquinone, halogenated ketones, acylphosphine oxides, and acylphosphonates. Non-limiting examples of the α -ketol compounds include 4-(2-hydroxyethoxy)phenyl (2-hydroxy-2-propyl) ketone, α -hydroxy- α,α' -dimethylacetophenone, 2-methyl-2-hydroxypropiophenone, and 1-hydroxycyclohexyl phenyl ketone. Non-limiting examples of the acetophenone compounds include methoxyacetophenone, 2,2-dimethoxy-1,2-diphenylethan-1-one, 2,2-diethoxyacetophenone, and 2-methyl-1-[4-(methylthio)-phenyl]-2-morpholinopropane-1. Non-limiting examples of the benzoin ether compounds include benzoin ethyl ether, benzoin isopropyl ether, and aniso-

methyl ether. A non-limiting example of the ketal compounds is benzil dimethyl ketal. A non-limiting example of the aromatic sulfonyl chloride compounds is 2-naphthalenesulfonyl chloride. A non-limiting example of the photoactive oxime compounds is 1-phenyl-1,2-propanedione-2-(O-ethoxycarbonyl)oxime. Non-limiting examples of the benzophenone compounds include benzophenone, benzoylbenzoic acid, and 3,3'-dimethyl-4-methoxybenzophenone. Non-limiting examples of the thioxanthone compounds include thioxanthone, 2-chlorothioxanthone, 2-methylthioxanthone, 2,4-dimethylthioxanthone, isopropylthioxanthone, 2,4-dichlorothioxanthone, 2,4-diethylthioxanthone, and 2,4-diisopropylthioxanthone. The radiation-curable pressure-sensitive adhesive to constitute the pressure-sensitive adhesive layer 22 may contain the photoinitiator in an amount of typically 0.05 to 20 parts by mass per 100 parts by weight of the base polymer such as an acrylic polymer.

[0066]

The pressure-sensitive adhesive layer 22, or the pressure-sensitive adhesive to constitute the layer 22, may further contain one or more types of other components in addition to the above-mentioned components. Non-limiting examples of such other components include cross-linking promoters; tackifiers; age inhibitors; and colorants such as pigments and dyes. The colorants may be compounds that are

colored by irradiation with radiation. Non-limiting examples of such compounds include leuco dyes.

[0067]

The pressure-sensitive adhesive layer 22 has a thickness of preferably 2 to 40 μm , more preferably 3 to 30 μm , and furthermore preferably 4 to 20 μm . The configuration as above is advantageous for providing balance in adhesive strength to the film 10 between before and after the radiation curing of the pressure-sensitive adhesive layer 22.

[0068]

In the film 10 of the dicing tape-combined adhesive sheet X, the surface 11a defined by the laser mark layer has a peel adhesion strength to a silicon wafer of 0.2 N/10 mm or less, preferably 0.1 N/10 mm or less, and more preferably 0.07 N/10 mm or less, in a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min. Specifically, techniques for preparing a test specimen to be subjected to the measurement and for performing the measurement are as follows. Initially, the pressure-sensitive adhesive layer 22 in the dicing tape-combined adhesive sheet X is irradiated with, and cured by, radiation such as ultraviolet radiation applied from the substrate 21 side at a cumulative dose of 300 mJ/cm². Next, the surface 12a defined by the adhesive layer of the film 10 of the dicing tape-combined

adhesive sheet X is laminated onto a single-coated pressure-sensitive adhesive tape BT-315 (trade name, supplied by Nitto Denko Corporation) to give a laminated article. This lamination is performed by a compression bonding operation through one reciprocating movement of a 2-kg hand roller. Next, a laminate is cut from the laminated article. The laminate has a multilayer structure including the dicing tape 20, the film 10, and the single-coated pressure-sensitive adhesive tape and has a size of 10 mm wide by 100 mm long. Next, the dicing tape 20 is removed (peeled) from the laminate. This gives a test specimen (10 mm wide by 100 mm long) having a multilayer structure including the single-coated pressure-sensitive adhesive tape and the film 10, from which the surface 11a defined by the laser mark layer is exposed. Next, the surface 11a defined by the laser mark layer of the film 10 in the test specimen is laminated onto a silicon wafer (for example, 6 inches in diameter) placed on a hot plate at a preset temperature of 80°C, after checking that the silicon wafer has a surface temperature of 75°C or higher. This lamination is performed by a compression bonding operation through one reciprocating movement of a 2-kg hand roller. After being left stand on the hot plate for 2 minutes, the resulting article is subjected to a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min using the tensile tester

Autograph AG-X (trade name, supplied by Shimadzu Corporation). Thus, the peel adhesion strength of the surface 11a defined by the laser mark layer of the film 10 to the silicon wafer is measured. This peel adhesion strength can be adjusted by selecting a catalyst to be used in the laser mark layer 11 and/or by adjusting drying conditions of the layer.

[0069]

The surface 12a defined by the adhesive layer in the film 10 of the dicing tape-combined adhesive sheet X has a peel adhesion strength to a silicon wafer of 5 N/10 mm or more, preferably 6 N/10 mm or more, and more preferably 7 N/10 mm or more, in a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min. The peel adhesion strength can be measured using a tensile tester Autograph AG-X (trade name, supplied by Shimadzu Corporation). Specifically, techniques for preparing a test specimen to be subjected to the measurement and for performing the measurement are as follows. Initially, the pressure-sensitive adhesive layer 22 in the dicing tape-combined adhesive sheet X is irradiated with, and cured by, radiation such as ultraviolet radiation applied from the substrate 21 side at a cumulative dose of 300 mJ/cm², and then the film 10 is peeled off from the dicing tape 20 of the dicing tape-combined adhesive sheet X. Next, the surface 11a defined by

the laser mark layer of the peeled film 10 is laminated onto a single-coated pressure-sensitive adhesive tape BT-315 (trade name, supplied by Nitto Denko Corporation) to give a laminated article. Next, a test specimen is cut from the laminated article, where the test specimen has a multilayer structure including the film 10 and the single-coated pressure-sensitive adhesive tape and has a size of 10 mm wide by 100 mm long. Next, the surface 12a defined by the adhesive layer of the film 10 in the test specimen is laminated onto a silicon wafer (for example, 6 inches in diameter) placed on a hot plate at a preset temperature of 80°C, after checking that the silicon wafer has a surface temperature of 75°C or higher. This lamination is performed by a compression bonding operation through one reciprocating movement of a 2-kg hand roller. After being left stand on the hot plate for 2 minutes, the resulting article is subjected to a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min using the tensile tester Autograph AG-X (trade name, supplied by Shimadzu Corporation). Thus, the peel adhesion strength of the surface 12a defined by the adhesive layer of the film 10 to the silicon wafer is measured. This peel adhesion strength can be adjusted typically by selecting the types of the resin components, such as acrylic resins, epoxy resins, and phenolic resins, in the adhesive layer 12, by adjusting the

contents of the resin components, and/or by adjusting the content of the inorganic filler.

[0070]

The dicing tape-combined adhesive sheet X has a first peel adhesion strength between the pressure-sensitive adhesive layer 22 after radiation curing and the film 10 of 0.15 N/20 mm or less, preferably 0.13 N/20 mm or less, and more preferably 0.09 N/20 mm or less, in a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min. The peel adhesion strength can be measured using a tensile tester Autograph AG-X (trade name, supplied by Shimadzu Corporation). Specifically, techniques for preparing a test specimen to be subjected to the measurement and for performing the measurement are as follows. Initially, the pressure-sensitive adhesive layer 22 in the dicing tape-combined adhesive sheet X is irradiated with, and cured by, radiation such as ultraviolet radiation applied from the substrate 21 side at a cumulative dose of 300 mJ/cm². Next, the surface 12a defined by the adhesive layer of the film 10 in the dicing tape-combined adhesive sheet X is laminated onto a single-coated pressure-sensitive adhesive tape BT-315 (trade name, supplied by Nitto Denko Corporation) to give a laminated article. This lamination is performed by a compression bonding operation through one reciprocating movement of a 2-kg hand roller. Next, a test

specimen is cut from the laminated article, where the test specimen has a multilayer structure including the dicing tape 20, the film 10, and the single-coated pressure-sensitive adhesive tape and has a size of 100 mm wide by 100 mm long. The test specimen is subjected to a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min using the tensile tester Autograph AG-X (trade name, supplied by Shimadzu Corporation), to measure the peel adhesion strength (first peel adhesion strength) between the pressure-sensitive adhesive layer 22 after radiation curing and the film 10 in the dicing tape-combined adhesive sheet X. This peel adhesion strength can be adjusted typically by adjusting the lamination temperature.

[0071]

The dicing tape-combined adhesive sheet X has a difference between a second peel adhesion strength and the first peel adhesion strength of 0.12 N/20 mm or less, preferably 0.1 N/20 mm or less, and more preferably 0.07 N/20 mm or less, where the second peel adhesion strength is a peel adhesion strength between the pressure-sensitive adhesive layer 22 after radiation curing and the film 10, after the storage of the dicing tape-combined adhesive sheet X at 50°C for 9 days, and is determined in a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min. The second peel adhesion strength can be measured

using a tensile tester Autograph AG-X (trade name, supplied by Shimadzu Corporation). Specifically, techniques for preparing a test specimen to be subjected to the measurement and for performing the measurement are as follows.

Initially, the dicing tape-combined adhesive sheet X is stored at an ambient temperature of 50°C for 9 days. Next, the pressure-sensitive adhesive layer 22 in the dicing tape-combined adhesive sheet X after the storage is irradiated with, and cured by, radiation such as ultraviolet radiation applied from the substrate 21 side at a cumulative dose of 300 mJ/cm². Next, the surface 12a defined by the adhesive layer of the film 10 in the dicing tape-combined adhesive sheet X is laminated onto a single-coated pressure-sensitive adhesive tape BT-315 (trade name, supplied by Nitto Denko Corporation) to give a laminated article. This lamination is performed by a compression bonding operation through one reciprocating movement of a 2-kg hand roller. Next, a test specimen is cut from the laminated article, where the test specimen has a multilayer structure including the dicing tape 20, the film 10, and the single-coated pressure-sensitive adhesive tape and has a size of 100 mm wide by 100 mm long. The test specimen is subjected to a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min using the tensile tester Autograph AG-X (trade name, supplied by Shimadzu Corporation), to measure the peel

adhesion strength (second peel adhesion strength) between the pressure-sensitive adhesive layer 22 after radiation curing and the film 10 in the dicing tape-combined adhesive sheet X. This peel adhesion strength can be adjusted typically by adjusting the storage environment such as storage temperature and/or storage humidity.

[0072]

The dicing tape-combined adhesive sheet X having the configurations as above can be produced typically by the following procedure.

[0073]

In the preparation of the film 10 in the dicing tape-combined adhesive sheet X, initially, a first resin film and a second resin film are separately prepared. The first resin film is a resin film to constitute the laser mark layer 11. The second resin film is a resin film to constitute the adhesive layer 12. The first resin film can be prepared by applying a resin composition for laser mark layer formation onto a predetermined separator to form a resin composition layer, and drying and curing the composition layer by heating. Non-limiting examples of the separator include poly(ethylene terephthalate) (PET) films, polyethylene films, polypropylene films, and plastic films and papers whose surfaces are each coated with a release agent such as a fluorocarbon release agent or a long-chain

alkyl acrylate release agent. Non-limiting examples of the application (coating) technique for the resin composition include roll coating, screen coating, and gravure coating. The heating in preparation of the first resin film is performed at a temperature of typically 90°C to 160°C for typically 2 to 4 minutes. On the other hand, the second resin film can be prepared by applying a resin composition for adhesive layer formation onto a predetermined separator to form a resin composition layer, and drying the composition layer by heating. The heating in preparation of the second resin film is performed at a temperature of typically 90°C to 150°C for typically 1 to 2 minutes. The first and second resin films can be prepared each in the form bearing the separator, by the above procedure. The exposed faces of the first and second resin films are laminated onto each other. This gives the film 10 having a multilayer structure including the laser mark layer 11 and the adhesive layer 12.

[0074]

The dicing tape 20 of the dicing tape-combined adhesive sheet X can be prepared by preparing a substrate 21, and providing a pressure-sensitive adhesive layer 22 on or over the substrate 21. For example, a resinous substrate 21 can be prepared by a film-forming technique such as filming by calender process, casting in an organic solvent, blow-

extrusion in a closed system, T-die extrusion, coextrusion, or dry laminating. The formed film or the substrate 21 may be subjected to a predetermined surface treatment as needed. In formation of the pressure-sensitive adhesive layer 22, for example, a pressure-sensitive adhesive composition for pressure-sensitive adhesive layer formation is prepared, and, initially, the composition is applied onto the substrate 21 or onto a predetermined separator to form a pressure-sensitive adhesive composition layer. Non-limiting examples of the technique for applying the pressure-sensitive adhesive composition include roll coating, screen coating, and gravure coating. Next, this pressure-sensitive adhesive composition layer is heated to be dried as needed and to undergo a crosslinking reaction as needed. The heating is performed at a temperature of typically 80°C to 150°C for typically 0.5 to 5 minutes. When the pressure-sensitive adhesive layer 22 is formed on a separator, the pressure-sensitive adhesive layer 22 with the separator is laminated onto the substrate 21, and then the separator is removed. This gives the dicing tape 20 having a multilayer structure including the substrate 21 and the pressure-sensitive adhesive layer 22.

[0075]

In the preparation of the dicing tape-combined adhesive sheet X, next, the laser mark layer 11 side of the film 10

is laminated onto the pressure-sensitive adhesive layer 22 side of the dicing tape 20. The lamination is performed at a temperature of typically 20°C to 50°C and a pressure (linear load) of typically 0.1 to 20 kgf/cm. Radiation such as ultraviolet radiation may be applied to the pressure-sensitive adhesive layer 22 before the lamination, or may be applied from the substrate 21 side to the pressure-sensitive adhesive layer 22 after the lamination. Alternatively, it is acceptable that such radiation irradiation is not performed during the production process of the dicing tape-combined adhesive sheet X. In this case, the pressure-sensitive adhesive layer 22 can be cured with radiation in the use process of the dicing tape-combined adhesive sheet X. When the pressure-sensitive adhesive layer 22 is curable with ultraviolet radiation, the ultraviolet radiation may be applied at an irradiance of typically 50 to 500 mJ/cm², so as to cure the pressure-sensitive adhesive layer 22. In the dicing tape-combined adhesive sheet X, there is a region (irradiation region R) which is to be irradiated with radiation to reduce the adhesive strength of the pressure-sensitive adhesive layer 22. This region is a region on which the film 10 is laminated, excluding the periphery thereof, in the pressure-sensitive adhesive layer 22, typically as illustrated in FIG. 1.

[0076]

The dicing tape-combined adhesive sheet X can be prepared by the above procedure. The dicing tape-combined adhesive sheet X may be provided with a separator (not shown) on the film 10 side, in such a form as to cover at least the film 10. Assume that the film 10 has a smaller size as compared with the pressure-sensitive adhesive layer 22 of the dicing tape 20, and the pressure-sensitive adhesive layer 22 has a region on which the film 10 is not present. In this case, the separator may be provided in such a form as to cover at least the film 10 and the pressure-sensitive adhesive layer 22. The separator is a constituent for protecting the film 10 and the pressure-sensitive adhesive layer 22 from being exposed and will be removed from the dicing tape-combined adhesive sheet X upon use of the film.

[0077]

FIGs. 2A, 2B, 3A, 3B, 4, 5, and 6 illustrate an exemplary semiconductor device production method in which the dicing tape-combined adhesive sheet X is used.

[0078]

In the semiconductor device production method, initially, a semiconductor wafer W is thinned by grinding (wafer thinning step or wafer back-grinding step), as illustrated in FIGs. 2A and 2B. The grinding can be performed using a grinder equipped with a grinding wheel.

The semiconductor wafer W has a first surface Wa and a second surface Wb. In the semiconductor wafer W, various semiconductor elements (not shown) have already been built in or on the first surface Wa side, and interconnection structures and other components (not shown) necessary for the semiconductor elements have been already formed on or over the first surface Wa. The second surface Wb is a so-called back surface (rear side). In the step, a wafer processing tape T1 having an adhesive face T1a is laminated onto the first surface Wa of the semiconductor wafer W, and the semiconductor wafer W is then ground from the second surface Wb to a predetermined thickness, while the semiconductor wafer W is held by the wafer processing tape T1. This yields a thinned semiconductor wafer 30.

[0079]

Next, the semiconductor wafer 30 held by the wafer processing tape T1 is laminated onto the film 10 of the dicing tape-combined adhesive sheet X or on the adhesive layer 12 of the film 10, as illustrated in FIG. 3A. Thereafter the wafer processing tape T1 is removed from the semiconductor wafer 30, as illustrated in FIG. 3B. The work may be then subjected to baking (baking step). Heating in the baking step may be performed at a temperature of typically 60°C to 80°C for 0.5 to 2 hours. Such baking may be performed so as to increase adhesion between the film 10

of the dicing tape-combined adhesive sheet X and the semiconductor wafer 30 appropriately.

[0080]

Next, the laser mark layer 11 of the film 10 in the dicing tape-combined adhesive sheet X is irradiated with a laser applied through the substrate 21 of the dicing tape 20, to perform laser marking (laser marking step). This laser marking marks information such as textual information and/or graphic information to each of the semiconductor elements, which will be diced into semiconductor chips. In the step, laser marking can be efficiently performed collectively on a large number of semiconductor elements in the semiconductor wafer 30 by a single laser marking process. Examples of the laser for use in the step include gas lasers and solid-state lasers. Non-limiting examples of the gas lasers include carbon dioxide laser (CO₂ laser) and excimer laser. A non-limiting example of the solid-state lasers is Nd:YAG laser.

[0081]

Next, after a ring frame 41 is attached onto the pressure-sensitive adhesive layer 22 in the dicing tape-combined adhesive sheet X, the work is cut by a dicing blade of a dicing saw (blade dicing step), as illustrated in FIG. 4. In FIG. 4, cut portions are schematically indicated by the thick lines. In the step, the semiconductor wafer 30 is

diced into semiconductor chips 31 and, with this, the film 10 of the dicing tape-combined adhesive sheet X is cut into pieced films 10'. This gives the semiconductor chip 31 each bearing the film 10' for back surface protective layer formation, namely, gives film-bearing semiconductor chips 31.

[0082]

In the dicing tape-combined adhesive sheet X, where the pressure-sensitive adhesive layer 22 of the dicing tape 20 has curability with radiation, the irradiation of the pressure-sensitive adhesive layer 22 with ultraviolet radiation or another radiation applied through the substrate 21 may be performed after the semiconductor chip dicing step, instead of the radiation irradiation in the production process for the dicing tape-combined adhesive sheet X. The irradiation may be performed at an irradiance of typically 50 to 500 mJ/cm². In the dicing tape-combined adhesive sheet X, there is a region (irradiation region R illustrated in FIG. 1) which is to be irradiated with radiation to reduce the adhesive strength of the pressure-sensitive adhesive layer 22. This region is typically a region on which the film 10 is laminated, excluding the periphery thereof, in the pressure-sensitive adhesive layer 22.

[0083]

Next, a cleaning step and/or an expanding step may be

performed as needed. The cleaning step is the step of cleaning, with a cleaning liquid such as water, the semiconductor chips 31 side of the dicing tape 20 bearing the film-bearing semiconductor chips 31. The expanding step is the step of expanding the separation distances between the film-bearing semiconductor chips 31. After one or both of these steps performed as needed, each film-bearing semiconductor chip 31 is picked up from the dicing tape 20 (picking-up step), as illustrated in FIG. 5. For example, while the dicing tape-combined adhesive sheet X with the ring frame 41 is held by a holder 42 of a picking-up device, a target film-bearing semiconductor chip 31 to be picked up is plunged up through the dicing tape 20 by a pin 43 of a picking-up mechanism, where the pin 43 is elevated from below the dicing tape 20 in the figure at a position corresponding to the target film-bearing semiconductor chip 31. The film-bearing semiconductor chip 31 is then sucked and held by a suction tool 44. In the picking-up step, the plunging up by the pin 43 is performed at a speed of typically 1 to 100 mm/sec to an amount (length) of typically 50 to 3000 μm .

[0084]

Next, the film-bearing semiconductor chip 31 is mounted on a packaging substrate 51 by a flip-chip technique, as illustrated in FIG. 6. Non-limiting examples of the

packaging substrate 51 include lead frames, tape automated bonding (TAB) films, and circuit boards. The semiconductor chip 31 is electrically coupled via bumps 52 to the packaging substrate 51. Specifically, an electrode pad (not shown) of the semiconductor chip 31 on its surface on which a circuit is to be formed is electrically coupled via the bumps 52 to a terminal area (not shown) of the packaging substrate 51. Example of the bumps 52 include solder bumps. A thermosetting (thermally curable) underfill 53 is disposed between the semiconductor chip 31 and the packaging substrate 51. The flip-chip mounting of the semiconductor chip 31 onto the packaging substrate 51 is actually performed typically by subjecting the packaging substrate 51 together with the film-bearing semiconductor chip 31 placed thereon to a so-called reflow process.

[0085]

A semiconductor device can be produced by the above procedure, where the semiconductor device includes the semiconductor chip 31 and the film 10' which is disposed on the back surface of the semiconductor chip 31 and serves as a protective film.

[0086]

The dicing tape-combined adhesive sheet X is also usable in a manner as follows, in a semiconductor device production process.

[0087]

In this semiconductor device production method, initially, modified regions 30a are formed in a semiconductor wafer W, as illustrated in FIGs. 7A and 7B. The semiconductor wafer W has a first surface Wa and a second surface Wb. In the semiconductor wafer W, various semiconductor elements (not shown) have already been built in or on the first surface Wa side, and interconnection structures and other components (not shown) necessary for the semiconductor elements have been already formed on or over the first surface Wa. The second surface Wb is a so-called back surface. In the step, a wafer processing tape T2 having an adhesive face T2a is laminated onto the first surface Wa of the semiconductor wafer W, and then, while the semiconductor wafer W is held by the wafer processing tape T2, laser beams, whose collecting spot is focused inside of the wafer, are applied to the semiconductor wafer W from the side opposite to the wafer processing tape T2, along lines along which the wafer will be divided (dividing lines). Thus, modified regions 30a are formed in the semiconductor wafer W due to ablation by multiphoton absorption. The modified regions 30a are embrittled regions for dividing the semiconductor wafer W into semiconductor chips. A technique for forming the modified regions 30a in the semiconductor wafer on the dividing lines by laser irradiation is

described in detail typically in JP-A No. 2002-192370. In the embodiment, laser irradiation conditions may be adjusted as appropriate typically within the following condition ranges.

[0088]

Laser Irradiation Conditions

(A) Laser Light

Laser source: diode-pumped Nd:YAG laser

Wavelength: 1064 nm

Laser spot cross-sectional area: $3.14 \times 10^{-8} \text{ cm}^2$

Laser form: Q switched pulse

Pulse rate: 100 kHz or less

Pulse width: 1 μs or less

Output: 1 mJ or less

Laser beam quality: TEM_{00}

Polarization property: linear polarization

(B) Condenser Lens

Magnifying power: 100x or less

Numerical aperture (NA): 0.55

Transmittance relative to laser beam wavelength: 100% or less

(C) Traveling speed of the table on which the semiconductor substrate is placed: 280 mm/sec or less

[0089]

Next, the semiconductor wafer W is thinned to a

predetermined thickness by grinding from the second surface Wb, while the semiconductor wafer W is held by the wafer processing tape T2, and this gives a semiconductor wafer 30A which can be diced into semiconductor chips 31 (wafer thinning step), as illustrated in FIG. 7C. The modified regions 30a in the semiconductor wafer 30A are exposed from the second surface Wb.

[0090]

The method may employ a technique of performing the step of forming modified regions 30a in the thinned wafer W by laser irradiation after a grinding step of grinding the wafer W to a predetermined thickness, instead of the technique of performing the wafer thinning step after the step of forming the modified regions 30a in the wafer W by laser irradiation. Even the alternative technique can yield a thin semiconductor wafer 30A capable of being diced into semiconductor chips 31.

[0091]

Next, the semiconductor wafer 30A held by the wafer processing tape T2 is laminated onto the film 10 of the dicing tape-combined adhesive sheet X, or onto the adhesive layer 12 of the film 10, as illustrated in FIG. 8A. The wafer processing tape T2 is then removed from the semiconductor wafer 30A, as illustrated in FIG. 8B.

[0092]

Typically thereafter, a laser is applied through the substrate 21 of the dicing tape 20 to the laser mark layer 11 of the film 10 in the dicing tape-combined adhesive sheet X, to perform laser marking (laser marking step). The laser marking gives textual information and/or graphical information to each of the semiconductor elements which will be diced into semiconductor chips. The step enables collective, efficient laser marking to a multiplicity of semiconductor elements in the semiconductor wafer 30A by a single laser marking process.

[0093]

The irradiation of the pressure-sensitive adhesive layer 22 through the substrate 21 with ultraviolet radiation or another radiation may be performed after the lamination of the semiconductor wafer 30A onto the film 10, instead of the radiation irradiation in the production process of the dicing tape-combined adhesive sheet X. The irradiation may be performed at an irradiance of typically 50 to 500 mJ/cm². In the dicing tape-combined adhesive sheet X, there is a region (irradiation region R illustrated in FIG. 1) which is to be irradiated with radiation to reduce the adhesive strength of the pressure-sensitive adhesive layer 22. This region is typically a region on which the film 10 is laminated, excluding the periphery thereof, in the pressure-sensitive adhesive layer 22.

[0094]

Next, after a ring frame 41 is attached onto the pressure-sensitive adhesive layer 22 of the dicing tape-combined adhesive sheet X, the dicing tape-combined adhesive sheet X bearing the semiconductor wafer 30A is secured to a holder 42 of an expander, as illustrated in FIG. 9A.

[0095]

Next, a first expanding step (cold expanding step for cleaving) at a relatively low ambient temperature is performed as illustrated in FIG. 9B, to dice or separate the semiconductor wafer 30A into semiconductor chips 31, and to cleave the film 10 of the dicing tape-combined adhesive sheet X into pieced films 10'. This gives film-bearing semiconductor chips 31. In the step, a hollow cylindrical plunge-up member 45 of the expander is elevated while coming in contact with the dicing tape 20 of the dicing tape-combined adhesive sheet X from below in the figure. This expands the dicing tape 20 of the dicing tape-combined adhesive sheet X, on which the semiconductor wafer 30A is laminated, so as to allow the dicing tape 20 to elongate in two-dimensional directions including the radial direction and the circumferential direction of the semiconductor wafer 30A. The expansion is performed under such conditions as to provide a tensile stress of typically 1 to 100 MPa in the dicing tape 20. In the step, the expansion may be performed

at an ambient temperature of typically 0°C or lower, preferably -20°C to -5°C, more preferably -15°C to -5°C, and furthermore preferably about -15°C; at an expansion speed (speed at which the plunge-up member 45 is elevated) of typically 1 to 500 mm/sec; and to an expansion amount (distance covered by the elevation of the plunge-up member 45) of typically 50 to 400 mm. With the cold expanding step as above, the film 10 of the dicing tape-combined adhesive sheet X is cleaved into pieced films 10' to give film-bearing semiconductor chips 31. Specifically, in the step, cracking occurs in the modified regions 30a, which are brittle, in the semiconductor wafer 30A, and this causes dicing of the semiconductor wafer 30A into the semiconductor chips 31. With this in the step, there are formed first regions and second regions in the film 10, where the film 10 adheres to the pressure-sensitive adhesive layer 22 of the dicing tape 20 to be expanded. The first regions are regions that adhere to the semiconductor chips 31 of the semiconductor wafer 30A and are effectively restrained from deforming; whereas the second regions are regions that correspond to or face the cracking portions of the wafer, and are acted upon by tensile stress occurring in the dicing tape 20 while receiving approximately no deformation restraining effect. This results in cleaving of the second regions in the film 10, where the second regions correspond

to the cracking portions between adjacent semiconductor chips 31. After the step, the plunge-up member 45 is lowered to release the dicing tape 20 from the expanded state, as illustrated in FIG. 9C.

[0096]

Next, a second expanding step at a relatively high ambient temperature is performed to broaden the distance (space) between film-bearing semiconductor chips 31, as illustrated in FIG. 10A. In the step, the hollow cylindrical plunge-up member 45 of the expander is elevated again, to expand the dicing tape 20 of the dicing tape-combined adhesive sheet X. The expansion in the second expanding step may be performed at an ambient temperature of typically 10°C or higher, and preferably 15°C to 30°C; at an expansion speed (speed at which the plunge-up member 45 is elevated) of typically 0.1 to 10 mm/sec to an expansion amount of typically 3 to 16 mm. In this step, the space between the film-bearing semiconductor chips 31 is broadened to such an extent that the film-bearing semiconductor chips 31 can be appropriately picked up from the dicing tape 20 in the after-mentioned picking-up step. After the step, the plunge-up member 45 is lowered to release the dicing tape 20 from the expanded state, as illustrated in FIG. 10B. It is preferred that a portion outside of the region in which the semiconductor chips 31 are held in the dicing tape 20 is

heated and thereby shrunk before the releasing from the expanded state. This is preferred so as to restrain narrowing of the space between the film-bearing semiconductor chips 31 over the dicing tape 20 after the releasing from the expanded state.

[0097]

The irradiation of the pressure-sensitive adhesive layer 22 from the substrate 21 side with ultraviolet radiation or another radiation may be performed after the first expanding step or the second expanding step, instead of the radiation irradiation in the production process of the dicing tape-combined adhesive sheet X, or instead of the radiation irradiation after the lamination of the semiconductor wafer 30A onto the film 10. The irradiation is performed at an irradiance of typically 50 to 500 mJ/cm². In the dicing tape-combined adhesive sheet X, there is a region (irradiation region R illustrated in FIG. 1) which is to be irradiated with radiation to reduce the adhesive strength of the pressure-sensitive adhesive layer 22. This region is typically a region on which the film 10 is laminated, excluding the periphery thereof, in the pressure-sensitive adhesive layer 22.

[0098]

Next, a cleaning step may be performed as needed. In the cleaning step, the semiconductor chips 31 side of the

dicing tape 20 with the film-bearing semiconductor chips 31 is cleaned with a cleaning liquid such as water. Thereafter, a picking-up step of picking-up each of the film-bearing semiconductor chips 31 from the dicing tape 20 is performed. Specifically, this step is performed by a procedure similar to that described above with reference to FIG. 5. Each of the resulting film-bearing semiconductor chips 31 is subjected to the mounting step, as described above with reference to FIG. 6. Thus, semiconductor devices can be produced.

[0099]

The surface 12a defined by the adhesive layer in the film 10 of the dicing tape-combined adhesive sheet X has a peel adhesion strength to a silicon wafer of 5 N/10 mm or more, preferably 6 N/10 mm or more, and more preferably 7 N/10 mm or more, in a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min, as described above. The configuration where the film 10 offers a peel adhesion strength to a silicon wafer at such a high level is suitable for actually allowing the dicing tape-combined adhesive sheet X or the film 10 of the sheet X to satisfactorily hold the work. The dicing tape-combined adhesive sheet X having such configuration does not always require curing by heating of the film 10 after lamination on the work, where the curing by heating is performed so as to offer higher

adhesion to the work. The dicing tape-combined adhesive sheet X is therefore suitable for avoiding or restraining excessive increase in adhesion of the film 10 to the pressure-sensitive adhesive layer 22 of the dicing tape 20. The dicing tape-combined adhesive sheet X as above is suitable for actually allowing the film-bearing semiconductor chips 31 to be satisfactorily picked up from the dicing tape 20 in a picking-up step as described above. [0100]

In the film 10 of the dicing tape-combined adhesive sheet X, the surface 11a defined by the laser mark layer has a peel adhesion strength of 0.2 N/10 mm or less, preferably 0.1 N/10 mm or less, and more preferably 0.07 N/10 mm or less, to a silicon wafer in a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min, as described above. The dicing tape-combined adhesive sheet X has a first peel adhesion strength between the pressure-sensitive adhesive layer 22 after radiation curing and the film 10 of 0.15 N/20 mm or less, preferably 0.13 N/20 mm or less, and more preferably 0.09 N/20 mm or less, as described above, where the first peel adhesion strength is a peel adhesion strength in a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min. These configurations relating to low peel adhesion strength is suitable for allowing the film 10 to surely have

removability from the pressure-sensitive adhesive layer 22 of the dicing tape 20 and, therefore, is suitable for allowing the film-bearing semiconductor chips 31 to be actually satisfactorily picked up from the dicing tape 20 in a picking-up step as described above. In addition, the configurations relating to low peel adhesion strength are advantageous for avoiding the film 10 from having excessive adhesion typically to the pressure-sensitive adhesive layer 22 of the dicing tape 20, even when the adhesion increases with time during storage period of the dicing tape-combined adhesive sheet X before use. The configurations contribute to control of the difference between a second peel adhesion strength and the first peel adhesion strength to be 0.12 N/20 mm or less, preferably 0.1 N/20 mm or less, and more preferably 0.07 N/20 mm or less, where the second peel adhesion strength is a peel adhesion strength between the pressure-sensitive adhesive layer 22 after radiation curing and the film 10, after the storage of the dicing tape-combined adhesive sheet X at 50°C for 9 days, and is determined in a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min. Specifically, the configurations relating to low peel adhesion strength are advantageous for surely providing storage stability on adhesion between the pressure-sensitive adhesive layer 22 of the dicing tape 20 and the film 10 or the laser mark layer

11 of the film 10. Assume that excessive increase in adhesion of the film 10 to the pressure-sensitive adhesive layer 22 of the dicing tape 20 is avoided as above, even if the adhesion increases with time. This contributes to actualization of satisfactory pick-up of the film-bearing semiconductor chips 31 from the dicing tape 20 in a picking-up step as described above.

[0101]

As described above, the dicing tape-combined adhesive sheet X is suitable as a dicing tape-combined back surface protective film for actually providing satisfactory pick-up of the film-bearing semiconductor chips 31 from the dicing tape 20.

[0102]

The film 10 has a ratio of the thickness of the laser mark layer 11 to the thickness of the adhesive layer 12 of preferably from 0.47 to 12, more preferably from 0.65 to 12, furthermore preferably from 0.75 to 7.5, and still more preferably from 0.85 to 5.5, as described above. Such configurations are preferred for allowing the film 10 to combine properties required of the surface defined by the laser mark layer 11 with properties required of the surface defined by the adhesive layer 12, which surface is opposite to the aforementioned surface and is a surface onto which the work will be laminated. Specifically, the

configurations are preferred for the laser mark layer 11 to surely provide the visibility of information marked by laser marking, and, compatibly with this, for allowing the surface defined by the adhesive layer to have satisfactory adhesiveness to the work. The ratio is preferably high, from the viewpoint of restraining cracking which may occur in wafer cut sections, namely, in chip sides due to impact and/or friction during cutting with a dicing blade, when the dicing tape-combined adhesive sheet X is used in a blade dicing step as described above. On the other hand, the ratio is preferably low, from the viewpoint of actually allowing the film 10 to be cleavable satisfactorily, when the dicing tape-combined adhesive sheet X is used in an expanding step for cleaving, as described above.

[0103]

In the embodiment, the dicing tape-combined adhesive sheet X has a difference between a second peel adhesion strength and the first peel adhesion strength of 0.12 N/20 mm or less, preferably 0.1 N/20 mm or less, and more preferably 0.07 N/20 mm or less, as described above, where the second peel adhesion strength is a peel adhesion strength between the pressure-sensitive adhesive layer 22 after radiation curing and the film 10, after the storage of the dicing tape-combined adhesive sheet X at 50°C for 9 days, and is determined in a peel test at 23°C, a peel angle

of 180°, and a tensile speed of 300 mm/min. Such configuration as above is suitable for actually providing satisfactory storage stability, by which increase with time is restrained, of adhesion between the pressure-sensitive adhesive layer 22 of the dicing tape 20 and the film 10 or the laser mark layer 11 of the film 10.

Examples

[0104]

Example 1

Back Surface Protective Film Preparation

In the preparation of a back surface protective film of a dicing tape-combined adhesive sheet, initially, a first resin film to constitute a laser mark layer (LM layer), and a second resin film to constitute an adhesive layer (AH layer) were separately prepared.

[0105]

In the first resin film preparation, initially, a resin composition having a solids concentration of 28 mass percent was prepared by combining and mixing methyl ethyl ketone with 100 parts by mass of an acrylic resin A₁ (trade name TEISANRESIN SG-P3, having a weight average molecular weight of 85×10^4 and a glass transition temperature T_g of 12°C, supplied by Nagase Chemtex Corporation), 52 parts by mass of an epoxy resin B₁ (trade name KI-3000-4, supplied by NIPPON STEEL & SUMIKIN CHEMICAL CO., LTD.), 22 parts by mass of an

epoxy resin B₂ (trade name JER YL980, supplied by Mitsubishi Chemical Corporation), 76 parts by mass of a phenolic resin C₁ (trade name MEH 7851-SS, supplied by Meiwa Plastic Industries, Ltd.), 188 parts by mass of a filler (trade name SO-25R, silica, having an average particle size of 0.5 μ m, supplied by Admatechs Company Limited), 25 parts by mass of a black dye (trade name OIL BLACK BS, supplied by Orient Chemical Industries Co., Ltd.), and 22 parts by mass of a curing catalyst Z₁ (trade name CUREZOL 2PZ, supplied by SHIKOKU CHEMICALS CORPORATION). Next, the resin composition was applied onto a surface, which had been subjected to a silicone surface release treatment, of a PET separator (50 μ m thick) using an applicator to form a resin composition layer. Next, the composition layer was dried and thermally cured by heating at 130°C for 2 minutes to form a 17- μ m thick first resin film (film to constitute a laser mark layer) on the PET separator.

[0106]

In the second resin film preparation, initially, a resin composition having a solids concentration of 28 mass percent was prepared by combining and mixing methyl ethyl ketone with 100 parts by mass of an acrylic resin A₁ (trade name TEISANRESIN SG-P3, supplied by Nagase Chemtex Corporation), 66 parts by mass of an epoxy resin B₃ (trade name EPPN-501HY, supplied by Nippon Kayaku Co., Ltd.), 84

parts by mass of a phenolic resin C₂ (trade name MEH 7851-H, supplied by Meiwa Plastic Industries, Ltd.), 177 parts by mass of a filler (trade name SO-25R, silica, having an average particle size of 0.5 μm , supplied by Admatechs Company Limited), and 15 parts by mass of a black dye (trade name OIL BLACK BS, supplied by Orient Chemical Industries Co., Ltd.). Next, the resin composition was applied onto a surface, which had been subjected to a silicone surface release treatment, of a PET separator (50 μm thick) using an applicator to form a resin composition layer. Next, the composition layer was dried by heating at 130°C for 2 minutes to form a 8- μm thick uncured second resin film (film to constitute an adhesive layer) on the PET separator.

[0107]

Using a laminator, the first resin film on the PET separator was laminated onto the second resin film on the PET separator, each prepared by the procedure as described above. Specifically, exposed faces of the first and second resin films were laminated onto each other at a temperature of 100°C and a pressure (load) of 0.6 MPa. Thus, a back surface protective film according to Example 1 was prepared. The formulations of the laser mark layer (LM layer) and the adhesive layer (AH layer) in Example 1 and after-mentioned examples and comparative examples are given in Tables 1 and 2, in which numerical values indicating the formulations of

the layers are indicated in relative "part by mass" in the layer.

[0108]

Dicing Tape Preparation

A mixture was stirred at 60°C in a nitrogen atmosphere for 10 hours (polymerization reaction) in a reactor equipped with a condenser, a nitrogen inlet tube, a thermometer, and a stirrer, where the mixture contained 100 parts by mass of 2-ethylhexyl acrylate, 19 parts by mass of 2-hydroxyethyl acrylate, 0.4 part by mass of benzoyl peroxide, which is a polymerization initiator, and 80 parts by mass of toluene, which is a polymerization solvent. This gave a polymer solution containing an acrylic polymer P₁. Next, a mixture was stirred at 50°C in an air atmosphere for 60 hours (addition reaction), where the mixture contained the polymer solution containing the acrylic polymer P₁, as well as 2-methacryloyloxyethyl isocyanate (MOI), and dibutyltin dilaurate, which is an addition reaction catalyst. In the reaction mixture, MOI was present in a proportion of 12 parts by mass per 100 parts by mass of the acrylic polymer P₁, and dibutyltin dilaurate was present in a proportion of 0.1 part by mass per 100 parts by mass of the acrylic polymer P₁. The addition reaction gave a polymer solution containing an acrylic polymer P₂ containing a methacrylate group in its side chain. Next, the polymer solution was

combined with and mixed with, per 100 parts by mass of the acrylic polymer P₂, 0.75 part by mass of a polyisocyanate compound (trade name CORONATE L, supplied by TOSOH CORPORATION), 2 parts by mass of a photoinitiator (trade name Irgacure 651, supplied by BASF SE), and toluene, and yielded a pressure-sensitive adhesive composition having a solids concentration of 28 mass percent. Next, using an applicator, the pressure-sensitive adhesive composition was applied onto a surface, which had been subjected to a silicone surface release treatment, of a PET separator (50 μ m thick) to form a pressure-sensitive adhesive composition layer. Next, the composition layer was dried by heating at 120°C for 2 minutes to form a 5- μ m thick pressure-sensitive adhesive layer on the PET separator. Next, using a laminator, the exposed face of the pressure-sensitive adhesive layer was laminated onto an ethylene-vinyl acetate copolymer (EVA) substrate (trade name NRW #125, 125 μ m thick, supplied by GUNZE Limited) at room temperature to give a laminated article. The laminated article was then stored at 23°C for 72 hours and yielded a dicing tape.

[0109]

Dicing Tape-Combined Back Surface Protective Film Preparation

The back surface protective film according to Example 1 with the PET separators was blanked into a circular piece

having a diameter of 330 mm. The dicing tape with the PET separator was blanked into a circular piece having a diameter of 370 mm. The PET separator at the laser mark layer side was removed from the back surface protective film, whereas the PET separator was removed from the dicing tape. After the removal, the exposed surface defined by the laser mark layer of the back surface protective film was laminated onto the exposed surface defined by the pressure-sensitive adhesive layer of the dicing tape, using a laminator. The lamination was performed at a lamination speed of 10 mm/min, a temperature of 23°C, and a pressure of 0.15 MP. The lamination was performed with alignment so that the center of the dicing tape agreed with the center of the back surface protective film. Thus, a dicing tape-combined back surface protective film according to Example 1 was prepared. This had a multilayer structure including the dicing tape and the back surface protective film.

[0110]

Example 2

A dicing tape-combined back surface protective film according to Example 2 was prepared by a procedure similar to that for the dicing tape-combined back surface protective film according to Example 1, except for, in the back surface protective film preparation, forming the first resin film (resin film to constitute a laser mark layer) so as to have

a thickness of 23 μm instead of 17 μm ; and forming the second resin film (resin film to constitute an adhesive layer) so as to have a thickness of 2 μm instead of 8 μm .

[0111]

Example 3

A dicing tape-combined back surface protective film according to Example 3 was prepared by a procedure similar to that for the dicing tape-combined back surface protective film according to Example 1, except for, in the back surface protective film preparation, forming the first resin film (resin film to constitute a laser mark layer) so as to have a thickness of 10 μm instead of 17 μm , and forming the second resin film (resin film to constitute an adhesive layer) so as to have a thickness of 15 μm instead of 8 μm .

[0112]

Example 4

A dicing tape-combined back surface protective film according to Example 4 was prepared by a procedure similar to that for the dicing tape-combined back surface protective film according to Example 1, except for, in the first resin film (resin film to constitute a laser mark layer) preparation, using 100 parts by mass of an acrylic resin A₂ (trade name TEISANRESIN SG-70L, having a weight average molecular weight of 90×10^4 and a glass transition temperature T_g of -13°C, supplied by Nagase Chemtex

Corporation) instead of 100 parts by mass of the acrylic resin A₁, using the epoxy resin B₁ (trade name KI-3000-4, supplied by NIPPON STEEL & SUMIKIN CHEMICAL CO., LTD.) in an amount of 43 parts by mass instead of 52 parts by mass, using the epoxy resin B₂ (trade name JER YL980, supplied by Mitsubishi Chemical Corporation) in an amount of 18 parts by mass instead of 22 parts by mass, using the phenolic resin C₁ (trade name MEH 7851-SS, supplied by Meiwa Plastic Industries, Ltd.) in an amount of 64 parts by mass instead of 76 parts by mass, using the filler (trade name SO-25R, supplied by Admatechs Company Limited) in an amount of 156 parts by mass instead of 188 parts by mass, using the black dye (trade name OIL BLACK BS, supplied by Orient Chemical Industries Co., Ltd.) in an amount of 21 part by mass instead of 25 parts by mass; and using the curing catalyst Z₁ (trade name CUREZOL 2PZ, supplied by SHIKOKU CHEMICALS CORPORATION) in an amount of 18 parts by mass instead of 22 parts by mass.

[0113]

Example 5

A dicing tape-combined back surface protective film according to Example 5 was prepared by a procedure similar to that for the dicing tape-combined back surface protective film according to Example 1, except for, in the first resin film (resin film to constitute a laser mark layer)

preparation, using 100 parts by mass of an acrylic resin A₂ (trade name TEISANRESIN SG-70L, having a weight average molecular weight of 90×10^4 and a glass transition temperature T_g of -13°C, supplied by Nagase Chemtex Corporation) instead of 100 parts by mass of the acrylic resin A₁, using the epoxy resin B₁ (trade name KI-3000-4, supplied by NIPPON STEEL & SUMIKIN CHEMICAL CO., LTD.) in an amount of 43 parts by mass instead of 52 parts by mass, using the epoxy resin B₂ (trade name JER YL980, supplied by Mitsubishi Chemical Corporation) in an amount of 18 parts by mass instead of 22 parts by mass, using the phenolic resin C₁ (trade name MEH 7851-SS, supplied by Meiwa Plastic Industries, Ltd.) in an amount of 64 parts by mass instead of 76 parts by mass, using the filler (trade name SO-25R, supplied by Admatechs Company Limited) in an amount of 156 parts by mass instead of 188 parts by mass, using the black dye (trade name OIL BLACK BS, supplied by Orient Chemical Industries Co., Ltd.) in an amount of 21 part by mass instead of 25 parts by mass; and using the curing catalyst Z₁ (trade name CUREZOL 2PZ, supplied by SHIKOKU CHEMICALS CORPORATION) in an amount of 7 parts by mass instead of 22 parts by mass.

[0114]

Example 6

A dicing tape-combined back surface protective film

according to Example 6 was prepared by a procedure similar to that for the dicing tape-combined back surface protective film according to Example 1, except for, in the back surface protective film preparation, forming the first resin film (resin film to constitute a laser mark layer) so as to have a thickness of 7 μm instead of 17 μm .

[0115]

Example 7

A dicing tape-combined back surface protective film according to Example 7 was prepared by a procedure similar to that for the dicing tape-combined back surface protective film according to Example 1, except for, in the back surface protective film preparation, forming the first resin film (resin film to constitute a laser mark layer) so as to have a thickness of 5 μm instead of 17 μm ; and forming the second resin film (resin film to constitute an adhesive layer) so as to have a thickness of 5 μm instead of 8 μm .

[0116]

Example 8

A dicing tape-combined back surface protective film according to Example 8 was prepared by a procedure similar to that for the dicing tape-combined back surface protective film according to Example 1, except for, in the back surface protective film preparation, forming the first resin film (resin film to constitute a laser mark layer) so as to have

a thickness of 8 μm instead of 17 μm ; and forming the second resin film (resin film to constitute an adhesive layer) so as to have a thickness of 17 μm instead of 8 μm .

[0117]

Comparative Example 1

A dicing tape-combined back surface protective film according to Comparative Example 1 was prepared by a procedure similar to that for the dicing tape-combined back surface protective film according to Example 1, except for, in the back surface protective film preparation, using the curing catalyst Z₁ (trade name CUREZOL 2PZ, supplied by SHIKOKU CHEMICALS CORPORATION) in an amount of 4 parts by mass instead of 22 parts by mass, to form first resin film (resin film to constitute a laser mark layer).

[0118]

Comparative Example 2

A resin composition having a solids concentration of 30 mass percent was prepared by combining and mixing methyl ethyl ketone with 100 parts by mass of the acrylic resin A₁ (trade name TEISANRESIN SG-P3, supplied by Nagase Chemtex Corporation), 9 parts by mass of an epoxy resin B₃ (trade name EPPN-501HY, supplied by Nippon Kayaku Co., Ltd.), 69 parts by mass of the phenolic resin C₁ (trade name MEH 7851-SS, supplied by Meiwa Plastic Industries, Ltd.), 12 parts by mass of the phenolic resin C₂ (trade name MEH 7851-H,

supplied by Meiwa Plastic Industries, Ltd.), and 7 parts by mass of the filler (trade name SO-25R, supplied by Admatechs Company Limited). Next, the resin composition was applied onto a surface, which had been subjected to a silicone surface release treatment, of a PET separator (50 μ m thick) using an applicator to form a resin composition layer. Next, the composition layer was dried by heating at 130°C for 2 minutes, to form a 25- μ m thick, back surface protective film on the PET separator. Except for using the back surface protective film according to Comparative Example 2 instead of the back surface protective film in Example 1, a dicing tape-combined back surface protective film according to Comparative Example 2 was prepared by a procedure similar to that for the dicing tape-combined back surface protective film according to Example 1.

[0119]

Comparative Example 3

A resin composition having a solids concentration of 30 mass percent was prepared by combining and mixing methyl ethyl ketone with 100 parts by mass of the acrylic resin A₂ (trade name TEISANRESIN SG-70L, supplied by Nagase Chemtex Corporation), 52 parts by mass of the epoxy resin B₁ (trade name KI-3000-4, supplied by NIPPON STEEL & SUMIKIN CHEMICAL CO., LTD.), 22 parts by mass of the epoxy resin B₂ (trade name JER YL980, supplied by Mitsubishi Chemical

Corporation), 76 parts by mass of the phenolic resin C₁ (trade name MEH 7851-SS, supplied by Meiwa Plastic Industries, Ltd.), 181 part by mass of the filler (trade name SO-25R, supplied by Admatechs Company Limited), 15 parts by mass of the black dye (trade name OIL BLACK BS, supplied by Orient Chemical Industries Co., Ltd.), and 6 parts by mass of a curing catalyst Z₂ (trade name CUREZOL 2PHZ-PW, supplied by SHIKOKU CHEMICALS CORPORATION). Next, the resin composition was applied onto a surface, which had been subjected to a silicone surface release treatment, of a PET separator (50 µm thick) using an applicator to form a resin composition layer. Next, the composition layer was dried by heating at 130°C for 2 minutes, to form a 25-µm thick, back surface protective film on the PET separator. Except for using the back surface protective film according to Comparative Example 3 instead of the back surface protective film according to Example 1, a dicing tape-combined back surface protective film according to Comparative Example 3 was prepared by a procedure similar to that for the dicing tape-combined back surface protective film according to Example 1.

[0120]

Thickness Measurement

Thickness measurements were performed by a procedure as follows on the laser mark layer (LM layer) and the adhesive

layer (AH layer) in each of the dicing tape-combined back surface protective films according to Examples 1 to 8 and Comparative Example 1, and on the back surface protective film in each of the dicing tape-combined back surface protective films according to Comparative Examples 2 and 3. Initially, a sample dicing tape-combined back surface protective film was frozen and then cut. Next, the cross section exposed as a result of the cutting was observed using a microscope (trade name digital microscope VHX-2000, supplied by Keyence Corporation), to measure the thickness of a measurement object layer. The maximum thickness (μm) of the measurement object layer is given in Tables 1 and 2.

[0121]

Peel Adhesion Strength f_1 of Back Surface Protective Film

In the back surface protective film of each of the dicing tape-combined back surface protective films according to Examples 1 to 8 and Comparative Examples 1 to 3, the surface facing the dicing tape was examined in peel adhesion strength f_1 to a silicon wafer by a procedure as follows. Initially, the pressure-sensitive adhesive layer in a sample dicing tape-combined back surface protective film was irradiated with, and cured by, ultraviolet radiation applied from the substrate side of the dicing tape at a cumulative dose of 300 mJ/cm^2 . Next, a work-mount surface of the back

surface protective film in the dicing tape-combined back surface protective film was laminated onto a single-coated pressure-sensitive adhesive tape BT-315 (trade name, supplied by Nitto Denko Corporation) to give a laminated article. This lamination was performed by a compression bonding operation through one reciprocating movement of a 2-kg hand roller. Next, a laminate was cut from the laminated article. The laminate had a multilayer structure including the dicing tape, the back surface protective film, and the single-coated pressure-sensitive adhesive tape and had a size of 10 mm wide by 100 mm long. Next, the dicing tape was removed from the laminate. This gave a test specimen (10 mm wide by 100 mm long) having a multilayer structure including the back surface protective film and the single-coated pressure-sensitive adhesive tape, where the surface of the back surface protective film, which had faced the dicing tape, was exposed. Next, the exposed surface of the back surface protective film in the test specimen was laminated onto a silicon wafer (6 inches in diameter) placed on a hot plate at a preset temperature of 80°C, after checking that the silicon wafer had a surface temperature of 75°C or higher. This lamination was performed by a compression bonding operation through one reciprocating movement of a 2-kg hand roller. After being left standing on the hot plate for 2 minutes, the resulting article was

subjected to a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min, using a tensile tester Autograph AG-X (trade name, supplied by Shimadzu Corporation). Thus, the peel adhesion strength f_1 (N/10 mm) of the surface, which had faced the dicing tape, of the back surface protective film to the silicon wafer was measured. The results are given in Tables 1 and 2. When interfacial peeling occurred at the interface between the single-coated pressure-sensitive adhesive tape BT-315 (trade name) and the adhesive layer of the back surface protective film in a sample, the peel adhesion strength f_1 of the sample is indicated as "≥ 8" (N/10 mm) (8 N/10 mm or more) in the tables.

[0122]

Peel Adhesion Strength f_2 of Back Surface Protective Film

In the back surface protective film in each of the dicing tape-combined back surface protective films according to Examples 1 to 8 and Comparative Examples 1 to 3, the work-mount surface (surface onto which the work is to be laminated) was examined in peel adhesion strength f_2 to a silicon wafer, by a procedure as follows. Initially, the pressure-sensitive adhesive layer in a sample dicing tape-combined back surface protective film was irradiated with, and cured by, ultraviolet radiation applied from the

substrate side of the dicing tape at a cumulative dose of 300 mJ/cm². The back surface protective film was then peeled off from the dicing tape of the dicing tape-combined back surface protective film. Next, the surface, which had faced the dicing tape, of the peeled back surface protective film was laminated onto a single-coated pressure-sensitive adhesive tape BT-315 (trade name, supplied by Nitto Denko Corporation). Next, from the resulting laminated article, a test specimen was cut. The test specimen had a multilayer structure including the back surface protective film and the single-coated pressure-sensitive adhesive tape and had a size of 10 mm wide by 100 mm long. Next, the work-mount surface of the back surface protective film in the test specimen was laminated onto a silicon wafer (6 inches in diameter) placed on a hot plate at a preset temperature of 80°C, after checking that the silicon wafer had a surface temperature of 75°C or higher. This lamination was performed by a compression bonding operation through one reciprocating movement of a 2-kg hand roller. After being left standing on the hot plate for 2 minutes, the resulting article was subjected to a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min, using a tensile tester Autograph AG-X (trade name, supplied by Shimadzu Corporation). Thus, the peel adhesion strength f_2 (N/10 mm) of the work-mount surface (surface onto which the work is to

be laminated) of the back surface protective film to the silicon wafer was measured. The results are given in Tables 1 and 2. When interfacial peeling occurred at the interface between the single-coated pressure-sensitive adhesive tape BT-315 (trade name) and the laser mark layer of the back surface protective film, the peel adhesion strength f_2 in the sample is indicated as " ≥ 8 " (N/10 mm) in the tables. [0123]

Peel Adhesion Strength F_1 between Pressure-Sensitive Adhesive Layer and Back Surface Protective Film

The dicing tape-combined back surface protective films according to Examples 1 to 8 and Comparative Examples 1 to 3 were each examined in peel adhesion strength F_1 (first peel adhesion strength) between the pressure-sensitive adhesive layer after radiation curing and the back surface protective film, by a procedure as follows. Initially, the pressure-sensitive adhesive layer of a sample dicing tape-combined back surface protective film was irradiated with, and cured by, ultraviolet radiation applied from the substrate side of the dicing tape at a cumulative dose of 300 mJ/cm². Next, the work-mount surface of the back surface protective film in the dicing tape-combined back surface protective film was laminated onto a single-coated pressure-sensitive adhesive tape BT-315 (trade name, supplied by Nitto Denko Corporation) to give a laminated article. This lamination

was performed by a compression bonding operation through one reciprocating movement of a 2-kg hand roller. Next, from the laminated article, a test specimen was cut. The test specimen had a multilayer structure including the dicing tape, the back surface protective film, and the single-coated pressure-sensitive adhesive tape and had a size of 100 mm wide by 100 mm long. The test specimen was subjected to a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min, using a tensile tester Autograph AG-X (trade name, supplied by Shimadzu Corporation). Thus, the peel adhesion strength F_1 (N/20 mm) between the pressure-sensitive adhesive layer after radiation curing and the back surface protective film in the dicing tape-combined back surface protective film was measured. The results are given in Tables 1 and 2.

[0124]

Peel Adhesion Strength F_2 between Pressure-Sensitive Adhesive Layer and Back Surface Protective Film

The dicing tape-combined back surface protective films according to Examples 1 to 8 and Comparative Examples 1 to 3 were each stored at an ambient temperature of 50°C for 9 days and then examined in peel adhesion strength F_2 (second peel adhesion strength) between the pressure-sensitive adhesive layer after radiation curing and the back surface protective film. The test specimen preparation technique,

and adhesive strength measurement technique and conditions for the examination of the peel adhesion strength F_2 are as with the test specimen preparation technique, and adhesive strength measurement technique and conditions for the examination of the peel adhesion strength F_1 . The measured peel adhesion strengths F_2 (N/20 mm) are given in Tables 1 and 2.

[0125]

Laser Markability Evaluation

The dicing tape-combined back surface protective films according to Examples 1 to 8 and Comparative Examples 1 to 3 were each examined in laser markability by a procedure as follows. Initially, a silicon wafer was laminated onto the back surface protective film of a sample dicing tape-combined back surface protective film using a laminator. This lamination was performed at a temperature of 80°C and a pressure of 0.15 MPa. Next, printing by laser marking was performed by applying laser light through the dicing tape to the back surface protective film surface, using laser marking equipment (trade name MD-S9910, supplied by Keyence Corporation). The laser marking was performed at a laser power of 0.23 W, a marking speed of 300 mm/sec, and a laser frequency of 10 kHz. Next, the pressure-sensitive adhesive layer was irradiated with, and cured by, ultraviolet radiation applied from the substrate side of the dicing tape

at a cumulative dose of 300 mJ/cm². The dicing tape was then removed from the back surface protective film disposed on the silicon wafer surface. Next, the back surface protective film-bearing silicon wafer was subjected to a reflow process three times using reflow equipment TAP30-407PM (trade name, supplied by TAMURA CORPORATION), where the reflow process was performed in a temperature profile (peak temperature: 260°C) in accordance with PIC/JEDEC J-STD-020. Before and after the three reflow processes, the portion printed by laser marking was observed using a microscope Digital Microscope VHX-5600 (trade name, supplied by Keyence Corporation). A sample on which the print by laser marking was clearly visually observed was evaluated as having good laser markability (Good); whereas a sample on which the print by laser marking was not clearly visually observed was evaluated as having poor laser markability (Poor). The results are given in Tables 1 and 2.

[0126]

Storage Stability Evaluation

The dicing tape-combined back surface protective films according to Examples 1 to 8 and Comparative Examples 1 to 3 were each examined in storage stability by a procedure as follows. Initially, a sample dicing tape-combined back surface protective film was stored at an ambient temperature of 50°C for 9 days. Next, a thinned silicon wafer (having a

diameter of 300 mm and a thickness of 200 μm) thinned by grinding was laminated onto the back surface protective film of the dicing tape-combined back surface protective film using a mounter MA3000III (trade name, supplied by Nitto Seiki Co., Ltd.). This lamination was performed at a temperature of 75°C, a pressure of 0.15 MPa, and a lamination speed of 10 mm/sec. Next, the silicon wafer on the dicing tape-combined back surface protective film was diced into semiconductor chips having a size of 4 mm by 4 mm, by blade dicing using a dicing saw DFD-6361 (trade name, supplied by DISCO Corporation). In this blade dicing, initially, the silicon wafer was cut to half the thickness thereof using a Z1 blade, and then the dicing tape substrate was cut to a depth of 15 μm using a Z2 blade. Each of the semiconductor chips diced by the above procedure bore a pieced film derived from the back surface protective film of the dicing tape-combined back surface protective film. Next, the pressure-sensitive adhesive layer was irradiated with, and cured by, ultraviolet radiation applied from the dicing tape substrate side of the dicing tape-combined back surface protective film at a cumulative dose of 300 mJ/cm². Next, a picking-up step of picking up the film-bearing semiconductor chips from the dicing tape was performed using a die bonder SPA-300 (trade name, supplied by SHINKAWA LTD.). The picking-up step was performed at an expansion

amount of 5 mm so as to expand the distance between adjacent semiconductor chips, a push-up speed by a plunge-up member of 160 mm/sec, and a push-up length by the plunge-up member of 200 μ m, in which the semiconductor chip was sucked up and held by a suction tool for 100 milliseconds. The storage stability was evaluated after trying picking up of 100 film-bearing semiconductor chips from the dicing tape. A sample enabling 90 or more film-bearing semiconductor chips to be picked up appropriately was evaluated as having very good storage stability (Very good); a sample enabling 70 to less than 90 film-bearing semiconductor chips to be picked up appropriately was evaluated as having good storage stability (Good); a sample enabling 50 to less than 70 film-bearing semiconductor chips to be picked up appropriately was evaluated as having fair storage stability (Fair); and a sample enabling 50 or less film-bearing semiconductor chips to be picked up appropriately was evaluated as having poor storage stability (Poor). The results are given in Tables 1 and 2.

[0127]

Evaluation

The dicing tape-combined back surface protective films according to Examples 1 to 8 each include a back surface protective film having satisfactory laser markability and are still suitable for actually allowing film-bearing

semiconductor chips to be picked up satisfactorily in a picking-up step.

[0128]

[Table 1]

	Example 1		Example 2		Example 3		Example 4		Example 5		Example 6	
	LM layer	AH layer	LM layer	AH layer	LM layer	AH layer	LM layer	AH layer	LM layer	AH layer	LM layer	AH layer
Acrylic resin A ₁ (TEISANRESIN SG-P3)	100	100	100	100	100	100	-	100	-	100	100	100
Acrylic resin A ₂ (TEISANRESIN SG-70L)	-	-	-	-	-	-	100	-	100	-	-	-
Epoxy resin B ₁ (KI-3000-4)	52	-	52	-	52	-	43	-	43	-	52	-
Epoxy resin B ₂ (JER YL980)	22	-	22	-	22	-	18	-	18	-	22	-
Epoxy resin B ₃ (EPPN-501HY)	-	66	-	66	-	66	-	66	-	66	-	66
Phenolic resin C ₁ (MEH 7851-SS)	76	-	76	-	76	-	64	-	64	-	76	-
Phenolic resin C ₂ (MEH 7851-H)	-	84	-	84	-	84	-	84	-	84	-	84
Filler (SO-25R)	188	177	188	177	188	177	156	177	156	177	188	177
Black dye (OIL BLACK BS)	25	15	25	15	25	15	21	15	21	15	25	15
Curing catalyst Z ₁ (CUREZOL 2PZ)	22	-	22	-	22	-	18	-	7	-	22	-
Curing catalyst Z ₂ (CUREZOL 2PHZ-PW)	-	-	-	-	-	-	-	-	-	-	-	-
Thickness (μm)	17	8	23	2	10	15	17	8	17	8	7	8
Ratio of LM layer thickness to AH layer thickness	2.1		11.5		0.67		2.1		2.1		0.88	
Peel adhesion strength f ₁ (N/10 mm)	0.01		0.01		0.01		0.08		0.19		0.01	
Peel adhesion strength f ₂ (N/10 mm)	≥ 8		≥ 8		≥ 8		≥ 8		≥ 8		≥ 8	
Peel adhesion strength F ₁ (N/20 mm)	0.08		0.08		0.08		0.10		0.13		0.06	
Peel adhesion strength F ₂ (N/20 mm)	0.13		0.13		0.13		0.18		0.25		0.11	
F ₂ - F ₁ (N/20 mm)	0.05		0.05		0.05		0.08		0.12		0.05	
Laser markability evaluation	Good		Good		Good		Good		Good		Good	
Storage stability evaluation	Very good		Very good		Very good		Good		Fair		Very good	

[0129]

[Table 2]

	Example 7		Example 8		Comp. Ex. 1		Comp. Ex. 2	Comp. Ex. 3
	LM layer	AH layer	LM layer	AH layer	LM layer	AH layer	Single layer	Single layer
Acrylic resin A ₁ (TEISANRESIN SG-P3)	100	100	100	100	100	100	100	-
Acrylic resin A ₂ (TEISANRESIN SG-70L)	-	-	-	-	-	-	-	100
Epoxy resin B ₁ (KI-3000-4)	52	-	52	-	52	-	-	52
Epoxy resin B ₂ (JER YL980)	22	-	22	-	22	-	-	22
Epoxy resin B ₃ (EPPN-501HY)	-	66	-	66	-	66	9	-
Phenolic resin C ₁ (MEH 7851-SS)	76	-	76	-	76	-	69	76
Phenolic resin C ₂ (MEH 7851-H)	-	84	-	84	-	84	12	-
Filler (SO-25R)	188	177	188	177	188	177	7	181
Black dye (OIL BLACK BS)	25	15	25	15	25	15	-	15
Curing catalyst Z ₁ (CUREZOL 2PZ)	22	-	22	-	4	-	-	-
Curing catalyst Z ₂ (CUREZOL 2PHZ-PW)	-	-	-	-	-	-	-	6
Thickness (μm)	5	5	8	17	17	8	25	25
Ratio of LM layer thickness to AH layer thickness	1		0.47		2.1		-	-
Peel adhesion strength f ₁ (N/10 mm)	0.01		0.01		0.25		6	≥ 8
Peel adhesion strength f ₂ (N/10 mm)	≥ 8		≥ 8		≥ 8		6	≥ 8
Peel adhesion strength F ₁ (N/20 mm)	0.06		0.08		0.08		0.08	0.09
Peel adhesion strength F ₂ (N/20 mm)	0.12		0.13		0.28		0.16	0.27
F ₂ - F ₁ (N/20 mm)	0.06		0.05		0.2		0.08	0.18
Laser markability evaluation	Good		Good		Poor		Poor	Poor
Storage stability evaluation	Very good		Very good		Poor		Very good	Poor

Reference Signs List

[0130]

X dicing tape-combined adhesive sheet

10, 10' film (adhesive sheet)

11 laser mark layer

11a, 12a surface

12 adhesive layer

20 dicing tape

21 substrate

22 pressure-sensitive adhesive layer

W, 30, 30A semiconductor wafer

30a modified region

31 semiconductor chip

51 packaging substrate

52 bump

CLAIMS

1. A dicing tape-combined adhesive sheet comprising:
a dicing tape having a multilayer structure including:
a substrate; and
a radiation-curable pressure-sensitive adhesive layer; and
an adhesive sheet having a multilayer structure including:
a laser mark layer; and
an adhesive layer,
the laser mark layer of the adhesive sheet removably adhering to the pressure-sensitive adhesive layer of the dicing tape,
in the adhesive sheet, a surface defined by the adhesive layer having a peel adhesion strength to a silicon wafer of 5 N/10 mm or more in a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min,
in the adhesive sheet, a surface defined by the laser mark layer having a peel adhesion strength to a silicon wafer of 0.2 N/10 mm or less in a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min,
the dicing tape-combined adhesive sheet having a first peel adhesion strength between the pressure-sensitive adhesive layer after radiation curing and the adhesive sheet

of 0.15 N/20 mm or less in a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min,

the dicing tape-combined adhesive sheet having a difference between a second peel adhesion strength and the first peel adhesion strength of 0.12 N/20 mm or less, where the second peel adhesion strength is a peel adhesion strength between the pressure-sensitive adhesive layer after radiation curing and the adhesive sheet, after storage of the dicing tape-combined adhesive sheet at 50°C for 9 days, and is determined in a peel test at 23°C, a peel angle of 180°, and a tensile speed of 300 mm/min.

2. The dicing tape-combined adhesive sheet according to claim 1,

wherein a ratio of a thickness of the laser mark layer to a thickness of the adhesive layer is from 0.47 to 12.

3. The dicing tape-combined adhesive sheet according to one of claims 1 and 2,

wherein the laser mark layer is a thermally cured thermosetting layer.

4. The dicing tape-combined adhesive sheet according to any one of claims 1 to 3,

wherein the adhesive layer is a thermoplastic layer.