

SEMICONDUCTOR PROCESSING TAPE

TECHNICAL FIELD

[0001] The present invention relates to a semiconductor processing tape that shows excellent pickup property.

Background Art

[0002] In the production of semiconductor devices such as integrated circuits (IC: Integrated Circuit), a backgrinding process of grinding the back side of the wafer to thin the wafer after circuit pattern formation, a dicing process of dividing the wafer into chip units after adhering a semiconductor processing tape that shows removable adhesiveness and elasticity on the back side of the wafer, an expand process of expanding the semiconductor processing tape, a pickup process of picking up the divided chip, and a die bonding (mount) process of bonding the picked up chip to a lead frame or package substrate (or in a stacked package, laminating and adhering chips together) are performed.

[0003] In the above-described backgrinding process, a surface protection tape is used to protect the circuit pattern-formed side of the wafer (wafer surface) from contamination. After grinding the back side of the wafer, in order to peel off this surface protection tape from the wafer surface, a later-described semiconductor processing tape (dicing-die bonding tape) is adhered to the back side of the wafer, the side with the semiconductor processing tape is fixed on to a suction table, the surface protection tape is subjected to a process that decreases its adhesiveness to the wafer, and the surface protection tape is peeled off. The wafer from which the surface protection tape has been peeled off is lifted off the suction table with the semiconductor processing tape bonded to its back side, and subjected to the next dicing process. Note that a process that decreases adhesiveness refers to an energy ray irradiation process when the surface protection tape is composed of an energy ray curing component such as ultraviolet ray, and refers to a heating process when the surface protection tape is composed of a heat-curable component.

[0004] In the dicing process to the mount process, following the above-described backgrinding process, a semiconductor processing tape with a removable adhesive layer and an adhesive layer laminated on a substrate film in this order is used. In general, when using a wafer, first, the wafer is fixed by adhering the adhesive layer of the semiconductor processing tape on the back side of the wafer, and the wafer and the adhesive layer is diced into chips using a dicing blade. Then, by expanding the tape toward the direction of the diameter, an expand process of expanding the distance between the chips is performed. This expand process is performed to enhance the recognizability of the chips by CCD cameras etc., as well as to prevent damages to the chips caused by adjacent chips coming into contact with each other, in the pickup process that follows. Subsequently, the chip is picked up along with the adhesive layer by peeling from the removable adhesive layer in the pickup process, and is directly adhered to the lead frame or package substrate etc. in the mount process. Thus, by using a semiconductor processing tape, chips with an adhesive layer attached thereto can be adhered directly to the lead frame and package substrate, and processes such as an adhesive agent application process, or a process of adhering die-bonding films onto each chip, can be omitted.

[0005] However, in the aforementioned dicing process, as described previously, because the wafer and the adhesive layer are diced together using a dicing blade, cutting wastes from the adhesive layer, as well as cutting waste from the wafer, develop. There was a problem in that when such cutting waste from the adhesive layer blocks the wafer groove generated by dicing, the chips stick to each other and cause pickup failure, which leads to a decrease in semiconductor device yield.

[0006] In order to solve such problems, a method of dicing only the wafer using the blade in the dicing process, and dividing the adhesive layer for each chip by expanding the semiconductor processing tape in the expand process, has been proposed. (For example, Patent Document 1.) In such a method of dividing the adhesive layer using the tension at expansion, cutting waste from the adhesive agent does not occur, and harmful effects on the pickup process can be avoided.

[0007] Furthermore, in recent years, as a method of dividing wafer, a method known as the stealth-dicing method, in which a wafer can be cut by a non-contact process using a laser-processing machine, has been proposed. For example, as a stealth-dicing method, in Patent Document 2, a method of cutting semiconductor substrate, which comprises a process of irradiating laser after setting the focus within the semiconductor substrate with a sheet attached thereto, to thereby create a modified region through multi-photon absorption within the semiconductor substrate, which serves as a predetermined division part, and a process of dividing the semiconductor substrate and the adhesive layer along the predetermined division part by expanding the sheet, is disclosed.

[0008] Further, as another method of cutting wafer using a laser-processing machine, for example, Patent Document 3 discloses a wafer division method that comprises a process of attaching an adhesive layer (adhesive film) for die bonding on the back side of a wafer, a process of adhering an extendable protective adhesive tape on the adhesive layer side of the wafer with the adhesive layer adhered thereto, a process of dividing into individual chips by irradiating laser from the surface of the wafer with the protective adhesive tape adhered thereto along a street, a process of cutting the adhesive layer for each chip by expanding the protective adhesive tape to thereby apply tension to the adhesive layer, and a process of detaching the chip with the cut adhesive layer attached thereto from the protective adhesive tape.

[0009] According to such wafer division methods disclosed in Patent Document 2 and Patent Document 3, the wafer is cut by a non-contact method by the irradiation of laser and the expansion of the tape, and thus, the physical load on the wafer is small. Cutting of the wafer can be performed without the development of cutting waste (chipping), as in the presently-common blade dicing. Further, since the adhesive layer is divided by expansion, cutting waste of the adhesive layer does not develop either. Thus, such methods are attracting attention as a superior technology that could replace blade dicing.

[0010] Furthermore, in Patent Document 4, in order to prevent the slack after

expansion from causing it to become difficult to maintain the space between chips stably, a method of maintaining space between the chips (hereinafter referred to as the "kerf width" by shrinking the tape after the expand process has been proposed.

RELATED ART

Patent Documents

[0011] Patent Document 1: JP2007-A-5530

Patent Document 2: JP2003-A-338467

Patent Document 3: JP2004-A-273895

Patent Document 4: JP2011-A-216508

SUMMARY

[0012] On the other hand, there was a problem in that the kerf width expansion could not be retained during the shrink process, causing re-adhering of the adhesive layer, which leads to defects occurring in the pickup process.

[0013] The present invention provides a semiconductor processing tape that shows excellent pickup properties and sufficient kerf width extension in the tape shrinkage process, thereby causing no displacement in chip position.

[0014] That is, the present invention relates to a semiconductor processing tape, which comprises a removable adhesive tape that is provided with a substrate film and a removable adhesive layer formed on at least one side of the substrate film, wherein, in the process of fragmenting the adhesive by expansion, when the tensile elongation of the removable adhesive tape according to the method of JIS7162 is 10%, the relationship between the stress of the substrate alone and the stress of the removable adhesive tape, is: $\text{stress on removable adhesive tape} / \text{stress on substrate alone} = 1$ or less.

[0015] Furthermore, the semiconductor processing tape is characterized in that in that it is utilized in a method for producing a semiconductor device, which comprises:
(a) a process of adhering a surface protection tape on the front side of a wafer on

which a circuit pattern has been formed;

- (b) a backgrinding process of grinding the back side of the wafer;
- (c) a process of adhering the adhesive layer of the semiconductor processing tape on the back side of the wafer, while heating the wafer;
- (d) a process of peeling the surface protection tape from the front side of the wafer;
- (e) a process of forming a modified region within the wafer through multiple-photon absorption by irradiating laser to a predetermined division part on the wafer;
- (f) an expand process of obtaining a plurality of chips with the adhesive layer attached thereto, by expanding the semiconductor processing tape to thereby divide the wafer and the adhesive layer of the semiconductor processing tape at the predetermined division part;
- (g) a process of maintaining space between the chips, by heat-shrinking a part of the expanded semiconductor processing tape that does not overlap with the chips, to thereby remove the slack that occur during the expand process; and
- (h) a pickup process of picking up the chip with the adhesive layer attached thereto from the removable adhesive layer of the semiconductor processing tape.

[0016] Further, the semiconductor processing tape is characterized in that in that it is utilized in a method for producing a semiconductor device, which comprises:

- (a) a process of adhering a surface protection tape on the front side of a wafer on which a circuit pattern has been formed;
- (b) a backgrinding process of grinding the back side of the wafer;
- (c) a process of adhering the adhesive layer of the semiconductor processing tape on the back side of the wafer, while heating the wafer;
- (d) a process of peeling the surface protection tape from the front side of the wafer;
- (e) a process of dividing the wafer into chips by irradiating laser along a division line on the front side of the wafer;
- (f) an expand process of obtaining a plurality of chips with the adhesive layer attached thereto, by expanding the semiconductor processing tape to thereby divide the adhesive layer for each chip;

(g) a process of maintaining space between the chips, by heat-shrinking a part of the expanded semiconductor processing tape that does not overlap with the chips, to thereby remove the slack that occur during the expand process; and

(h) a pickup process of picking up the chip with the adhesive layer attached thereto from the removable adhesive layer of the semiconductor processing tape.

[0017] Furthermore, the semiconductor processing tape is characterized in that in that it is utilized in a method for producing a semiconductor device, which comprises:

(a) a process of adhering a surface protection tape on the front side of a wafer on which a circuit pattern has been formed;

(b) a backgrinding process of grinding the back side of the wafer;

(c) a process of adhering the adhesive layer of the semiconductor processing tape on the back side of the wafer, while heating the wafer;

(d) a process of peeling the surface protection tape from the wafer surface;

(e) a process of dividing the wafer into chips by cutting along a division line using a dicing blade;

(f) an expand process of obtaining a plurality of chips with the adhesive layer attached thereto, by expanding the semiconductor processing tape to thereby divide the adhesive layer for each chip;

(g) a process of maintaining space between the chips by heat-shrinking a part of the expanded semiconductor processing tape that does not overlap with the chips, to thereby remove the slack that occur during the expand process; and

(h) a pickup process of picking up the chip with the adhesive layer attached thereto from the removable adhesive layer of the semiconductor processing tape.

[0018] Further, the semiconductor processing tape is characterized in that in that it is utilized in a method for producing a semiconductor device, which comprises:

(a) a process of cutting a wafer on which a circuit pattern has been formed up to a depth that is smaller than the thickness of the wafer along a predetermined division line using a dicing blade;

(b) a process of adhering a surface protection tape on the front side of the wafer

- (c) a backgrinding process of grinding the back side of the wafer to thereby divide the wafer into chips;
- (d) a process of adhering the adhesive layer of the semiconductor processing tape on the back side of the wafer that is divided into chips, while heating the wafer;
- (e) a process of peeling the surface protection tape from the front side of the wafer that has been divided into the chips;
- (f) an expand process of obtaining a plurality of chips with the adhesive layer attached thereto, by expanding the semiconductor processing tape to thereby divide the adhesive layer for each chip;
- (g) a process of maintaining space between the chips by heat-shrinking a part of the expanded semiconductor processing tape that does not overlap with the chips, to thereby remove the slack that occur during the expand process; and
- (h) a pickup process of picking up the chip with the adhesive layer attached thereto from the removable adhesive layer of the semiconductor processing tape.

[0019] Further, the semiconductor processing tape is characterized in that in that it is utilized in a method for producing a semiconductor device, which comprises:

- (a) a process of adhering a surface protection tape on the front side of a wafer on which a circuit pattern has been formed;
- (b) a process of forming a modified region within the wafer through multiple-photon absorption by irradiating laser to a predetermined division part on the wafer;
- (c) a backgrinding process of grinding the back side of the wafer;
- (d) a process of adhering the adhesive layer of the semiconductor processing tape on the back side of the wafer, while heating the wafer;
- (e) a process of peeling the surface protection tape from the front side of the wafer;
- (f) an expand process of obtaining a plurality of chips with the adhesive layer attached thereto, by expanding the semiconductor processing tape to thereby divide the wafer and the adhesive layer of the semiconductor processing tape at the division part;
- (g) a process of maintaining space between the chips, by heat-shrinking a part of the expanded semiconductor processing tape that does not overlap with the chips, to thereby

remove the slack that occur during the expand process; and

(h) a pickup process of picking up the chip with the adhesive layer attached thereto from the removable adhesive layer of the semiconductor processing tape.

[0020] Furthermore, the present invention relates to a semiconductor device that utilizes the semiconductor processing tape.

Effect of the Invention

[0021] By using the semiconductor processing tape of the present invention, the even expansion without change in the kerf width is made possible. Thus, a highly reliable semiconductor device, in which the chip position does not deviate and pickup defect does not occur, can be obtained.

BRIEF DESCRIPTION OF DRAWINGS

[0022] [FIG. 1] FIG. 1 is a cross-sectional diagram that shows the structure of the semiconductor processing tape of an embodiment of the present invention.

[FIG. 2] FIG. 2 is a cross-sectional diagram that shows a state in which a surface protection tape is adhered to wafer.

[FIG. 3] FIG. 3 is a cross-sectional diagram that describes the process of adhering a wafer and a ring frame to the semiconductor processing tape of the present invention.

[FIG. 4] FIG. 4 is a cross-sectional diagram that describes the process of peeling the surface protection tape from the front side of a wafer.

[FIG. 5] FIG. 5 is a cross-sectional diagram that describes the formation of a modified region in the wafer by laser processing.

[FIG. 6] FIG. 6(a) is a cross-sectional diagram that shows the semiconductor processing tape of the present invention mounted on an expansion machine; FIG. 6 (b) is a cross-sectional diagram that shows the process of dividing the wafer into chips by expanding the semiconductor processing tape; FIG. 6 (c) is a cross-sectional diagram that shows the semiconductor processing tape, the adhesive layer, and the chip after expansion.

[FIG. 7] FIG. 7 is a cross-sectional diagram that describes the heat-shrinking process.

DESCRIPTION OF SOME EMBODIMENTS

[0023] <Semiconductor Processing Tape>

FIG. 1 is a cross-sectional diagram showing an embodiment of the semiconductor processing tape 10 of the present invention. In the semiconductor processing tape 10 of the present invention, the adhesive layer 13 is divided along the chip when the wafer is divided into chips by expansion. This semiconductor processing tape 10 comprises a substrate film 11, a removable adhesive layer 12 formed on the substrate film 11, and an adhesive layer 13 formed on the removable adhesive layer 12, and the back side of the wafer is adhered to the adhesive layer 13. Note that each layer may be cut in a predetermined shape (pre-cut) according to the process or machine to be used. Further, the semiconductor processing tape 10 of the present invention may be in a form that is cut for each wafer, or may be in a roll form, wherein a long sheet with a plurality of tapes cut out for each wafer is rolled.

[0024] The semiconductor processing tape of the present invention comprises a removable adhesive tape that is provided with a substrate film and a removable adhesive layer formed on at least one side of the substrate film, and it is required that in the process of fragmenting the adhesive by expansion, when the tensile elongation of the removable adhesive tape according to the method of JIS7162 is 10%, the relationship between the stress of the substrate alone and the stress of the removable adhesive tape is:

stress on removable adhesive tape/stress on substrate alone = 1 or less.

[0025] Specifically, a sample of 25 mm width is prepared and attached to a tensile testing machine so that the distance between the chucks is 50 mm, and the value obtained after stretching 5 mm, that is 10%, at a rate of 100 mm/min and holding for 60 seconds was measured.

Note that the above "stress of the removable adhesive tape" refers to the stress

of the semiconductor processing tape 10 of the present invention that is collected after the expand process in the method for producing a semiconductor device.

Further, the above "stress of the substrate alone" refers to the stress of the substrate film 11 on its own prior to forming the removable adhesive layer on the substrate film 11.

[0026] By satisfying the above condition, the kerf width is sufficiently secured and a remarkable effect of good pickup without the occurrence of wrinkles or displacement of chips is accomplished.

[0027] Although there are various means of controlling the physical property of the semiconductor processing tape, a method of performing energy ray curing treatment before the expand treatment, or known methods of biaxial co-extrusion and heat-set treatment can be applied to suitably control the physical property.

Hereinafter, compositions of each layer of the semiconductor processing tape will be described.

[0028] <Substrate Film>

The material of the substrate film 11 is favorable when it shows uniform and isotropic expandability in the expand process, since the wafer can be divided without deviation in all directions, and its material is not particularly limited. In general, crosslinked resins show larger restoring force against stretching compared to non-crosslinked resin, and shows large shrinkage stress when heated at an expanded state after the expand process. Therefore, the slack that occur to the tape after the expand process can be removed by heat-shrinking to thereby stably maintain the distance between individual chips by applying stress to the tape. Among crosslinked resins, thermoplastic crosslinked resins are more favorably used. On the other hand, non-crosslinked resins show smaller restoring force against stretching compared to crosslinked resins. Therefore, when they are relaxed after an expand process in a low-temperature range such as -15 °C to 0 °C and returned to normal temperature, the tape is less likely to shrink while heading for the pickup process and the mount process. Thus, they are superior in that the adhesive layers on the chips can be prevented from

coming in contact with each other. Among non-crosslinked resins, olefin-type non-crosslinked resins are more preferably used.

[0029] As such thermoplastic crosslinked resin, for example, ionomer resins obtained by crosslinking ethylene-(meth)acrylic acid binary copolymers or terpolymers having ethylene-(meth)acrylic acid-(meth)acrylic acid alkyl ester as its main polymer component with metal ions, are exemplified. These resins are suitable for the expand process, since they can be expanded uniformly, and are especially favorable since they show strong restoring force with heating by crosslinking. The metal ion contained in the above ionomer resin is not particularly limited, but zinc, sodium, and such may be listed. However, zinc ion shows low leachability and is especially preferable from the viewpoint of low contamination. In the meth(acrylic) acid alkyl ester of the above terpolymer, alkyl chains with 1 to 4 carbons show high elastic modulus and is preferable from the point of being able to spread strong force to the wafer. As such meth(acrylic) acid alkyl ester, methyl (meth)acrylate, ethyl (meth)acrylate, propyl(meth)acrylate, butyl (meth)acrylate, and the like may be listed.

[0030] Further, as such thermoplastic crosslinked resin, other than the above-described ionomer resins, those obtained by crosslinking resins selected from low density polyethylene with a specific gravity of 0.910 or more to less than 0.930, ultra low density polyethylene with a specific gravity of less than 0.910, and ethylene-vinyl acetate copolymer, by irradiating energy rays such as electron ray, are also preferable. In such thermoplastic crosslinked resins, crosslinked parts and non-crosslinked parts coexist within the resin, and thus, show constant uniform expandability. Further, since strong restoring force works when heated, it is also preferable for removing the slack that occur to the tape in the expand process. Also, since the molecular chain composition contains almost no chlorine, even when the unnecessary tape is combusted after used, chlorinated aromatic hydrocarbons such as dioxin and its analogues are not generated, and burden on the environment is low. By appropriately adjusting the amount of energy ray irradiated to the polyethylene or the ethylene-vinyl acetate copolymer, a resin that shows sufficient uniform expandability can be obtained.

[0031] Further, as the non-crosslinked resin, for example, mixed resin composition of polypropylene and styrene-butadiene copolymer may be exemplified.

[0032] As polypropylene, for example, a single polymer of propylene or a block or random-type propylene-ethylene copolymer can be utilized. Random-type propylene-ethylene copolymer show small rigidity and are preferable. When the content of the ethylene composition unit in the propylene-ethylene copolymer is 0.1 wt% or more, the rigidity of the tape and the compatibility of the resins in the mixed resin composition becomes high and is superior. When the rigidity of the tape is appropriate, the cutting property of the wafer increases and when the solubility of the resin is high, the extrusion rate tends to be stable. More favorable is 1 wt% or more. Further, when the content of the ethylene composition unit in the propylene-ethylene copolymer is 7 wt% or less, it is preferable in that the polypropylene is easily and steadily polymerizable. More favorable is 5 wt% or less.

[0033] As the styrene-butadiene copolymer, one that is hydrogenated may be used. When styrene-butadiene copolymer is hydrogenated, good compatibility with propylene is obtained and brittleness and color change due to oxidation decomposition caused by the double bond in butadiene can be prevented. Further, when the styrene component content of the styrene-butadiene copolymer is 5 wt% or more, the styrene-butadiene copolymer is easily and stably polymerized and is thus favorable. Further, at 40 wt% or less, it becomes flexible and expandable and is thus superior. More favorable is 25 wt% or less, and further preferable is 15 wt% or less. As the styrene-butadiene copolymer, a block-type copolymer and random-type copolymer can both be used. Random-type copolymers are preferable since the styrene phase is dispersed evenly and suppresses the rigidity from becoming too large, therefore enhancing its expandability.

[0034] When the content of polypropylene in the mixed resin composition is 30 wt% or more, it is superior in that irregularities in the thickness of the substrate film can be suppressed. When the thickness is uniform, the expandability tends to become isotropic. Further, it becomes easy to prevent the stress relaxation of the substrate film

to become excessively large, thereby causing the distance between the chips to decrease with time and the adhesive layers to come in contact with each other and re-adhere. More preferable is 50 wt% or more. Further, when the content of the polypropylene is 90 wt% or less, the rigidity of the substrate film can easily be adjusted appropriately. When the rigidity of the substrate film is excessively large, large force is required to expand the substrate film and burden on the machine becomes large, which may make it impossible to provide sufficient expansion to the wafer and adhesive layer 13 for division. Thus, appropriate adjustment is important. The minimum amount of the styrene-butadiene copolymer in the mixed resin composition is preferably 10 wt% or more, to make it easy to adjust the rigidity of the substrate film to that appropriate for the machine. The maximum amount is preferable 70 wt% or less, since the irregularities in the thickness can be suppressed. More favorable is 50 wt% or less.

[0035] Note that in FIG. 1, the substrate film 11 is of a single layer, but it is not limited to such, and may have a multiple-layered structure with 2 or more types of resins laminated, or 2 or more layers of 1 type of resin may be laminated. When using 2 or more types of resins, if crosslinked or non-crosslinked resins are unified, it is preferable in that the property can be enhanced and expressed. If crosslinked or non-crosslinked resins are laminated in combination, it is preferable in that the disadvantages of each can be supplemented. The thickness of the substrate film 11 is not particularly regulated, and may be in a range that can easily be expanded in the expand process of the semiconductor processing tape 10 and show sufficient strength to not break. For example, about 50 to 300 μm is preferable, and 70 to 200 μm is further preferable. Further, it is preferable that the substrate film 11 contains crystalline resins.

[0036] As the method of producing a substrate film 11 with multiple layers, known methods of extrusion and lamination may be used. When the lamination method is used, adhesives may be interposed between the layers. As such adhesive, known adhesives may be used.

[0037] <Removable Adhesive Layer>

The removable adhesive layer 12 can be formed by applying a removable adhesive composition onto the substrate film 11. The removable adhesive layer 12 that constitutes the semiconductor processing tape 10 of the present invention may be any type, as long as it does not peel from the adhesive layer 13 during dicing, shows enough retention to avoid defects such as chip displacement, and shows properties that enable easy peeling from the adhesive layer 13 during pickup.

[0038] In the semiconductor processing tape 10 of the present invention, the constituent of the removable adhesive composition that constitute the removable adhesive layer 12 is not particularly limited. However, to improve the pickup property after dicing, one that is energy ray-curable is preferable, and a material that becomes easy to peel from the adhesive layer 13 after curing is further preferable. As one embodiment, a removable adhesive composition that comprises, as a base resin, a polymer (A) that contains 60 mol% or more of (meth)acrylate having an alkyl chain of 6 to 12 carbons, and an energy ray-curable carbon-carbon double bond with an iodine value of 5 to 30, is exemplified. Note that in the present application, energy ray refers to light rays such as ultraviolet ray, or ionizing radiation such as electron ray.

[0039] In such polymer (A), when the iodine value of the energy ray-curable carbon-carbon double bond is 5 or more, the decreasing effect of the adhesive force after energy ray irradiation becomes high and is thus favorable. The iodine value is more preferably 10 or more. Further, when the iodine value is 30 or less, the retentivity of the chip until pickup after energy ray irradiation becomes high, and the distance between the chips can easily be expanded before the pickup process, and is thus superior. When the distance between the chips is sufficiently expanded before the pickup process, image recognition of each chip at pickup becomes easy, and pickup becomes easy, and is thus favorable. Further, when the iodine value is 5 or more to 30 or less, the polymer (A) itself becomes stable, and easy to produce.

[0040] Furthermore, when the polymer (A) has a glass transition temperature of -70 °C or higher, its heat resistance during energy ray irradiation becomes excellent, and more favorable is -66 °C or higher. Further, when the glass transition temperature is

15 °C or lower, the effect of chip-scattering prevention after dicing a wafer with a rough surface becomes excellent. More preferable is 0 °C or lower, and further preferable is -28 °C or lower.

[0040] The aforementioned polymer (A) may be produced by any method. For example, one that is obtained by mixing an acrylic copolymer with a compound that contains energy ray-curable carbon-carbon double bonds, and one that is obtained by reacting an acrylic copolymer containing a functional group or a methacrylic copolymer containing a functional group (A1) with a compound that contains a functional group that can react with such functional groups and contains energy ray-curable carbon-carbon double bonds (A2), can be used.

[0042] Among these, as the above-described methacrylic copolymer containing a functional group (A1), one that is obtained by copolymerizing a monomer that contains carbon-carbon double bonds (A1-1), as in alkyl acrylates and alkyl methacrylates, with a monomer that contains carbon-carbon double bonds and a functional group (A-2), can be exemplified. As the monomer (A1-1), hexyl acrylate, n-octyl acrylate, isooctyl acrylate, 2-ethylhexyl acrylate, dodecyl acrylate, decyl acrylate, each having alkyl chains of 6 to 12 carbon atoms, or monomers having alkyl chains of 5 or less carbon atoms such as pentyl acrylate, n-butyl acrylate, isobutyl acrylate, ethyl acrylate, and methyl acrylate, as well as similar methacrylates, are listed.

[0043] Note that in the monomer (A1-1), the components with alkyl chains of 6 or more carbon atoms can decrease the peeling force between the removable adhesive layer and the adhesive layer, and thus, excels in the point of pickup property. Further, the components with alkyl chains of 12 or less carbon atoms show low elastic modulus at room temperature, and excel in the point of adhesive force at the interface between the removable adhesive layer and the adhesive layer. When the adhesive force at the interface between the removable adhesive layer and the adhesive layer is high, the interfacial deviation between the removable adhesive layer and the adhesive layer can be suppressed when the wafer is divided by expanding the tape, and thus, division property is enhanced, and is thus preferable.

[0044] Further, as monomer (A1-1), since the glass transition temperature decreases with the use of monomers with larger numbers of carbon atoms in the alkyl chain, by adequately choosing the monomer, a removable adhesive composition with a desired glass transition temperature can be prepared. Further, besides the glass transition temperature, for the purpose of enhancing various performances such as compatibility, low molecular weight compounds containing carbon-carbon double bonds, such as vinyl acetate, styrene, and acrylonitrile, may be added. In this case, such low molecular weight compounds should be added within the range of 5 % by mass or less of the entire mass of the monomer (A1-1).

[0045] On the other hand, as the functional group which the monomer (A1-2) contains, carboxyl group, hydroxyl group, amino group, cyclic acid anhydride group, epoxy group, and isocyanate group, etc., can be listed. Specific examples of the monomer (A1-2) include acrylic acid, methacrylic acid, cinnamic acid, itaconic acid, fumaric acid, phthalic acid, 2-hydroxyalkyl acrylates, 2-hydroxyalkyl methacrylates, glycol monoacrylates, glycol monomethacrylates, N-methylol acrylamide, N-methylol methacrylamide, allyl alcohol, N-alkylaminoethyl acrylates, N-alkylaminoethyl methacrylates, acrylamides, methacrylamides, maleic anhydride, itaconic anhydride, fumaric anhydride, phthalic anhydride, glycidyl acrylate, glycidyl methacrylate, and allyl glycidyl ether.

[0046] Further, when the functional group in compound (A1) is a carboxyl group or a cyclic acid anhydride group, the functional group to be used in compound (A2) include a hydroxyl group, an epoxy group, an isocyanate group, and the like; when the functional group in compound (A1) is a hydroxyl group, the functional group to be used in compound (A2) include a cyclic acid anhydride group, an isocyanate group, and the like; when the functional group in compound (A1) is an amino group, the functional group to be used in compound (A2) include an epoxy group, an isocyanate group, and the like; and when the functional group in compound (A1) is an epoxy group, the functional group to be used in compound (A2) include a carboxyl group, a cyclic acid anhydride group, an amino group, and the like. Specific examples of compound (A2)

include those listed as examples of monomer (A1-2). Further, as compound (A2), polyisocyanate compounds with parts of the isocyanate group urethanized by monomers having a hydroxyl group or a carboxyl group and an energy ray-curable carbon-carbon double bond, can also be used.

[0047] Note that in the reaction of compound (A1) and compound (A2), by leaving some of the functional groups unreacted, products with desired properties, such as the acid value and hydroxyl value, can be produced. By leaving OH groups so that the hydroxyl value of polymer (A) is 5 to 100, the removable adhesive strength after irradiation of energy ray can be reduced to further decrease the risk of pickup mistakes. Further, by leaving COOH group so that the acid value of the polymer (A) is 0.5 to 30, the restoration property of the removable adhesive layer after expanding the semiconductor processing tape is effectively improved, and is thus preferable. Here, if the hydroxyl value of the polymer (A) is too low, the removable adhesion strength after irradiation of energy ray cannot be effectively reduced, and if it is too high, the fluidity of the removable adhesive agent after irradiation of energy ray tends to be impaired. Further, if the acid value is too low, the tape recovery property is not effectively improved, and if it is too high, the fluidity of the removable adhesive agent tends to be impaired.

[0048] In the synthesis of the above-described polymer (A), the organic solvent to be used when carrying out the reaction by solution polymerization may be one of a ketone-type, ester-type, alcohol-type, or aromatic-type. Among these, those that are generally good solvents for acrylic polymers, with a boiling point of 60 to 120 °C, such as toluene, ethyl acetate, isopropyl alcohol, benzene methyl cellosolve, ethyl cellosolve, acetone, methyl ethyl ketone, and the like, are preferable. As the polymerization initiator, radical generators of azobis-type such as α,α' -azobisisobutyronitrile, and of organic peroxide-type such as benzoylperoxide, are usually used. In such case, catalysts and polymerization inhibitors, and the like may optionally be added as required. By controlling the polymerization temperature and polymerization time, a polymer (A) with a desired molecular weight can be obtained. Further, for controlling

the molecular weight, the use of mercaptan-type or carbon tetrachloride-type solvent is preferable. Note that the reaction is not limited to solution polymerization, and other methods such as bulk polymerization, suspension polymerization, and the like, may be applied.

[0049] Although the polymer (A) can be obtained by the above methods, in the present invention, the molecular weight of the polymer (A) is preferably about 500,000 to 1,000,000. When the molecular weight is less than 500,000, its cohesive force decreases, and shear tends to occur at the interface with the adhesive layer during expansion; tensile force is not sufficiently propagated to the adhesive layer, and division of the adhesive layer may become insufficient. In order to prevent such shear as much as possible, the molecular weight should preferably be 500,000 or more. Further, when the molecular weight exceeds 1,000,000, gelation may occur during synthesis and application. Note that in the present invention, the molecular weight refers to the polystyrene conversion mass-average molecular weight.

[0050] Further, in the semiconductor processing tape 10 of the present invention, the resin composition constituting the removable adhesive layer 12 may contain a compound (B) that serves as a crosslinking agent, along with the polymer (A). In particular, it is at least one compound selected from polyisocyanates, melamine formaldehyde resins, and epoxy resins. These may be used independently or by combining two or more. This compound (B) reacts with the polymer (A) or the substrate film, and the resulting crosslinking construction enhances the cohesive force of the removable adhesive agent, which contains the polymer (A) and the compound (B) as its main component, after applying the removable adhesive composition.

[0051] As polyisocyanates, there are no particular limits, and aromatic isocyanates such as 4,4'-diphenylmethane diisocyanate, tolylene diisocyanate, xylylene diisocyanate, 4,4'-diphenylether diisocyanate, and 4,4'-[2,2-bis(4-phenoxyphenyl)propane] diisocyanate, as well as hexamethylene diisocyanate, 2,2,4-trimethyl-hexamethylene diisocyanate, isophorone diisocyanate, dicyclohexylmethane 4-4'-diisocyanate, dicyclohexylmethane 2-4'-diisocyanate, lysine

diisocyanate, lysine triisocyanate, etc. are exemplified. In particular, Colanate L (manufactured by Nippon Polyurethane Industry Co., Ltd.; trade name) and the like, can be used. As melamine formaldehyde resin, in particular, NIKALAC MX-45 (manufactured by Sanwa Chemical Co. Ltd.; trade name), Melan (manufactured by Hitachi Chemical Co. Ltd.; trade name), and the like, can be used. As epoxy resins, TETRAD-X (manufactured by Mitsubishi Chemical Co. Ltd., trade name) etc. can be used. In the present invention, the use of polyisocyanates is particularly preferable.

[0052] The amount of compound (B) added is selected so that the composition becomes 0.1 to 10 parts by mass, preferably 0.5 to 5 parts by mass, for 100 parts by mass of polymer (A). By selecting in this range, the cohesive force can be controlled at a suitable range and crosslinking does not proceed too rapidly, allowing good workability of the removable adhesive agent, such as mixing and application.

[0053] Furthermore, in the present invention, it is preferable that the removable adhesive layer 12 contains a photoinitiator (C). The type of photoinitiator (C) is not particularly limited, and those conventionally known can be used. For example, benzophenones such as benzophenone, 4,4'-dimethylaminobenzophenone, 4,4'-diethylaminobenzophenone, 4,4'-dichlorobenzophenone, etc., acetophenones such as acetophenone, diethoxyacetophenone, etc., anthraquinones such as 2-ethyl anthraquinone, t-butyl anthraquinone, etc., 2-chlorothioxanthone, benzoin ethyl ether, benzoin isopropyl ether, benzyl 2,4,5-triarylimidazole dimer (Iophine dimer), acridine-type compound, and the likes, can be listed. These may be used independently, or by combining 2 or more. The amount of the photoinitiator (C) added is preferably 0.1 to 10 parts by mass, or more preferably, 0.5 to 5 parts by mass, for 100 parts by mass of polymer (A).

[0054] Further, the energy ray-curable removable adhesive agent used in the present invention, a tackifier, an adhesion regulating agent, a surfactant, and other modifying agents may be added, as required. Moreover, inorganic fillers may also be arbitrarily added.

[0055] The removable adhesive layer 12 may be formed using conventional

methods of forming a removable adhesive layer. For example, the removable adhesive layer 12 may be formed on the substrate film 11 by a method of applying the above-described removable adhesive composition on an arbitrary surface of the substrate film 11, or by a method of applying the above-described removable adhesive composition on a separator (for example, a plastic film or sheet on which a release agent has been applied, and such) to form a removable adhesive layer 12, and then transferring the removable adhesive layer 12 on to an arbitrary surface of the substrate. Note that the removable adhesive layer 12 may be in the form of a single layer or may be in the form of a laminate.

[0056] The thickness of the removable adhesive layer is not particularly limited, but when the thickness is 2 μm or more, it is superior in the point of tack strength, and 5 μm or more is further preferable. When the thickness is 15 μm or less, the pickup property becomes excellent and 10 μm or less is further preferable.

[0057] <Adhesive Layer>

In the semiconductor processing tape of the present invention, the adhesive layer 13 is peeled from the removable adhesive layer 12 and attached to the chip, after it is adhered to a wafer, which is diced into chips, and the chip is picked up. Subsequently, it is used as an adhesive agent for fixing the chip on a substrate or lead frame.

[0058] The adhesive layer 13 is not particularly limited, and may be an adhesive agent of film-form that is generally used for wafers. For example, those having thermoplastic resins and thermally polymerizable components may be listed. The thermoplastic resin used in the adhesive layer 13 of the present invention is preferably a resin that shows thermoplasticity or a resin that shows thermoplasticity in the uncured state and forms a crosslinked structure after heating, and is not particularly limited. As one embodiment, a thermoplastic resin with a weight-average molecular weight of 5000 to 200,000 and a glass-transition temperature of 0 to 150 $^{\circ}\text{C}$ may be listed. Further, as another embodiment, a thermoplastic resin with a weight-average molecular weight of 100,000 to 1,000,000 and a glass-transition temperature of -50 to 20 $^{\circ}\text{C}$ may

be listed.

[0059] As the first thermoplastic resin, for example, polyimide resin, polyamide resin, polyether imide resin, polyamide imide resin, polyester resin, polyester imide resin, phenoxy resin, polysulfone resin, polyether sulfone resin, polyphenylene sulfide resin, polyether ketone resin, and the like may be listed. In particular, the use of polyimide resin and phenoxy resin is favorable, and as the second thermoplastic resin, the use of polymers with functional groups is favorable.

[0060] Polyimide resins can be obtained by subjecting tetracarboxylic dianhydride and diamine to a known method of condensation reaction. That is, about equimolar amounts of tetracarboxylic dianhydride and diamine are subjected to addition reaction in an organic solvent, at a reaction temperature of 80 °C or lower, preferably 0 to 60 °C. As the reaction proceeds, the viscosity of the reaction solution slowly increases, and polyamic acid, a precursor of polyimide, is generated. The molecular weight of this polyamic acid can be controlled by subjecting to depolymerization by heating at a temperature of 50 to 80 °C. Polyimide resin can be obtained by cyclodehydration of the above reactant (polyamic acid). Cyclodehydration can be performed by heat cyclization, in which heat treatment is performed, or chemical cyclization, which utilizes a dehydrating agent.

[0061] The tetracarboxylic dianhydride used as the raw material for the polyimide resin is not particularly limited, and for example, 1,2-(ethylene) bis (trimellitate anhydride), 1,3-(trimethylene) bis (trimellitate anhydride), 1,4-(tetramethylene) bis (trimellitate anhydride), 1,5-(pentamethylene) bis (trimellitate anhydride), 1,6-(hexamethylene) bis (trimellitate anhydride), 1,7-(heptamethylene) bis (trimellitate anhydride), 1,8-(octamethylene) bis (trimellitate anhydride), 1,9-(nonamethylene) bis (trimellitate anhydride), 1,10-(decamethylene) bis (trimellitate anhydride), 1,12-(dodecamethylene) bis (trimellitate anhydride), 1,16-(hexadecamethylene) bis (trimellitate anhydride), 1,18-(octadecamethylene) bis (trimellitate anhydride), pyromellitic dianhydride, 3,3',4,4'-biphenyltetracarboxylic acid dianhydride, 2,2',3,3'-biphenyltetracarboxylic acid dianhydride,

2,2-bis(3,4-dicarboxyphenyl) propane dianhydride, 2,2-bis(2,3-dicarboxyphenyl) propane dianhydride, 1,1-bis(2,3-dicarboxyphenyl) ethane dianhydride, 1,1-bis(3,4-dicarboxyphenyl) ethane dianhydride, bis(2,3-dicarboxyphenyl) methane dianhydride, bis(3,4-dicarboxyphenyl) methane dianhydride, bis(3,4-dicarboxyphenyl) sulfone dianhydride, 3,4,9,10-perylene tetracarboxylic acid dianhydride, bis(3,4-dicarboxyphenyl) ether dianhydride, benzene-1,2,3,4- tetracarboxylic acid dianhydride, 3,4,3',4'-benzophenone tetracarboxylic acid dianhydride, 2,3,2',3'-benzophenone tetracarboxylic acid dianhydride, 3,3,3',4'-benzophenone tetracarboxylic acid dianhydride, 1,2,5,6-naphthalene tetracarboxylic acid dianhydride, 1,4,5,8-naphthalene tetracarboxylic acid dianhydride, 2,3,6,7-naphthalene tetracarboxylic acid dianhydride, 1,2,4,5-naphthalene tetracarboxylic acid dianhydride, 2,6-dichloronaphthalene-1,4,5,8- tetracarboxylic acid dianhydride, 2,7-dichloronaphthalene-1,4,5,8- tetracarboxylic acid dianhydride, 2,3,6,7-tetrachloronaphthalene-1,4,5,8- tetracarboxylic acid dianhydride, phenanthrene-1,8,9,10-tetracarboxylic acid dianhydride, pyrazine-2,3,5,6-tetracarboxylic acid dianhydride, thiophene-2,3,5,6-tetracarboxylic acid dianhydride, 2,3,3',4-biphenyltetracarboxylic acid dianhydride, 3,4,3',4'-biphenyltetracarboxylic acid dianhydride, 2,3,2',3'-biphenyltetracarboxylic acid dianhydride, bis (3,4-dicarboxyphenyl) dimethylsilane dianhydride, bis (3,4-dicarboxyphenyl) methylphenylsilane dianhydride, bis (3,4-dicarboxyphenyl) diphenylsilane dianhydride, 1,4-bis (3,4-dicarboxyphenyl dimethylsilyl) benzene dianhydride, 1,3-bis (3,4-dicarboxyphenyl)-1,1,3,3-tetramethyl dicyclohexane dianhydride, p-phenylene bis (trimellitate anhydride), ethylene tetracarboxylic acid dianhydride, 1,2,3,4-butane tetracarboxylic acid dianhydride, decahydronaphthalene-1,4,5,8- tetracarboxylic acid dianhydride, 4,8-dimethyl-1,2,3,5,6,7-hexahydro naphthalene-1,2,5,6- tetracarboxylic acid dianhydride, cyclopentane-1,2,3,4- tetracarboxylic acid dianhydride, pyrrolidine-2,3,4,5- tetracarboxylic acid dianhydride, 1,2,3,4-cyclobutane tetracarboxylic acid dianhydride, bis(exobicyclo[2,2,1]heptane-2,3-dicarboxylic acid

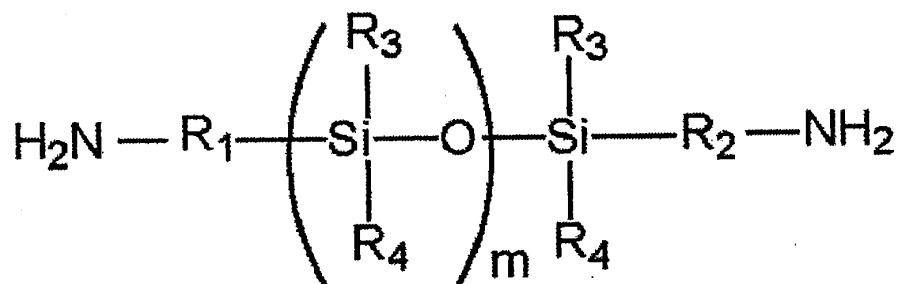
dianhydride, bicycle-[2,2,3]-oct-7-ene-2,3,5,6- tetracarboxylic acid dianhydride, 2,2-bis(3,4-dicarboxyphenyl) hexafluoropropane dianhydride, 2,2-bis[4-(3,4-dicarboxyphenyl) phenyl] hexafluoropropane dianhydride, 4,4-bis(3,4-dicarboxyphenoxy) diphenylsulfide dianhydride, 1,4-bis(2-hydroxyhexafluoroisopropyl) benzene bis trimellitic acid anhydride, 1,3-bis(2-hydroxyhexafluoroisopropyl) benzene bis trimellitic acid anhydride, 5-(2,5-dioxotetrahydrofuryl)-3-methyl-3-cyclohexene-1,2-dicarboxylic acid dianhydride, tetrahydrofuran-2,3,4,5-tetracarboxylic acid dianhydride, and the like may be used. One of these may be used, or two or more types may be used in combination.

[0062] The diamine used as the raw material for polyimide is not particularly limited, and for example, o-phenylenediamine, m-phenylenediamine, p-phenylenediamine, 3,3'-diaminodiphenyl ether, 3,4'-diaminodiphenyl ether, 4,4'-diaminodiphenyl ether, 3,3'-diaminodiphenylmethane, 3,4'-diaminodiphenylmethane, 4,4'-diaminodiphenylether methane, bis(4-amino-3,5-dimethylphenyl)methane, bis(4-amino-3,5-diisopropylphenyl)methane, 3,3'-diaminodiphenyldifluoro methane, 3,3'-diaminodiphenylsulfone, 3,3'-diaminodiphenylsulfide, 3,4'-diaminodiphenyl sulfide, 4,4'-diaminodiphenyl sulfide, 3,3'-diaminodiphenylketone, 2,2-bis(3-aminophenyl) propane, 2,2'-(3,4'-diaminodiphenyl)propane, 2,2-bis(4-aminophenyl) propane, 2,2-bis(3-aminophenyl)hexafluoropropane, 2,2-(3,4'-diaminodiphenyl) hexafluoropropane, 2,2-bis(4-aminophenyl) hexafluoropropane, 1,3-bis(3-aminophenoxy) benzene, 1,4-bis(3-aminophenoxy) benzene, 1,4-bis(4-aminophenoxy) benzene, 3,3'-(1,4-phenylene bis (1-methylethylidene)) bis aniline, 3,4'-(1,4-phenylene bis (1-methylethylidene)) bis aniline, 4,4'-(1,4-phenylene bis (1-methylethylidene)) bis aniline, 2,2-bis(4-(3-aminophenoxy)phenyl) propane, 2,2-bis(4-(4-aminophenoxy)phenyl) propane, 2,2-bis(4-(3-aminophenoxy)phenyl) hexafluoropropane, 2,2-bis(4-(4-aminophenoxy)phenyl) hexafluoropropane, bis(4-(3-aminophenoxy)phenyl) sulfide, bis(4-(4-aminophenoxy)phenyl) sulfide, bis(4-(3-aminophenoxy)phenyl) sulfone, bis(4-(4-aminophenoxy)phenyl) sulfone, aromatic diamines such as 3,5-diaminobenzoic acid, 1,2-diaminoethane,

1,3-diaminopropane, 1,4-diaminobutane, 1,5-diaminopentane, 1,6-diaminohexane, 1,7-diaminoheptane, 1,8-diaminooctane, 1,9-diaminononane, 1,10-diaminodecane, 1,11-diamino undecane, 1,12-diaminododecane, 1,2-diaminocyclohexane, diaminopolysiloxane expressed by the following general formula (1), 1,3-bis(aminomethyl)cyclohexane, polyoxyalkylenediamine such as JEFFAMINE D-230, D-400, D-2000, D-4000, ED-600, ED-900, ED-2001, and EDR-148 by Sun Techno Chemicals, Inc., and the like may be used. One of these may be used, or two or more types may be used in combination. As the glass transition temperature of such polyimide resin, 0 to 200 °C is preferable and the weight-average molecular weight is preferably 10,000 to 200,000.

[0063] General Formula (1)

[Chemical Formula 1]



(in the formula, R₁ and R₂ are divalent hydrocarbons with 1 to 30 carbon atoms, which may be the same or different, and R₃ and R₄ are monovalent hydrocarbons, which may be the same or different.)

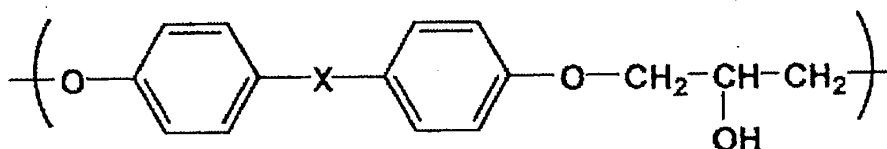
[0064] Other than the above, phenoxy resin is one favorable thermoplastic resin. Those that can be obtained by reacting various bisphenols with epichlorohydrin, or by reacting liquid epoxy resins with bisphenols are preferable. As the bisphenol, bisphenol A, bisphenol AF, bisphenol AD, bisphenol F, bisphenol S may be listed. Since phenoxy resins are similar in structure with epoxy resins, they are highly

compatible with epoxy resins and are favorable in adding good adhesiveness to the adhesive film.

[0065] As a phenoxy resin that is used in the present invention, for example, a resin having the repeating units expressed by the following general formula (2) may be listed.

[0066] General Formula (2)

[Chemical Formula 2]



[0067] In the above general formula (2), X is a single bond or a divalent connecting group. As a divalent connecting group, alkylene, phenylene, -O-, -S-, -SO- or -SO₂- may be listed. Here, the alkylene is preferably an alkylene group with 1 to 10 carbon atoms, and -C(R₅)(R₆)- is further preferable. R₅ and R₆ are hydrogen atoms or an alkyl group, and as such alkyl group, linear or branched alkyl groups of 1 to 8 carbons are preferable. For example, methyl, ethyl, n-propyl, isopropyl, isooctyl, 2-ethylhexyl, 1,3,3-trimethylbutyl, and the like may be listed. Further, such alkyl group may be substituted with a halogen atom, an example of which is a trifluoromethyl group. X is preferably an alkylene group, -O-, -S-, fluorene group or -SO₂-, and more preferably an alkylene group or -SO₂-. In particular, -C(CH₃)₂-, -CH(CH₃)-, -CH₂-, -SO₂- are preferable. -C(CH₃)₂-, -CH(CH₃)- and -CH₂- are more preferable and -C(CH₃)₂- is particularly preferable.

[0068] The phenoxy resin expressed by the above general formula (2) may be a resin having repeating units of general formula (2) with different X, or may be composed entirely of repeating units having the same X, as long as it contains the repeating unit. In the present invention, resins composed entirely of repeating units with the same X are preferable.

[0069] Further, by adding polar substituents such as hydroxyl group and carboxyl group, its compatibility with thermally polymerizable components can be increased, thereby allowing an even appearance and property.

[0070] When the mass-average molecular weight of the phenoxy resin is 5000 or larger, it becomes excellent in film formation property. More preferable is 10,000 or larger, and further preferable is 30,000 or larger.

Further, the mass-average molecular weight is preferably 150,000 or smaller from the point of fluidity during thermal press-bonding and compatibility with other resins. More preferable is 100,000 or smaller. Further, when the glass transition temperature is -50 °C or higher, it becomes excellent in film forming property. More preferable is 0 °C or higher, and further preferable is 50 °C or higher. When the glass transition temperature is 150 °C, excellent the adhesiveness in the adhesive layer 13 during die bonding is obtained. More preferable is 120 °C or lower and further preferable is 110 °C or lower.

[0071] On the other hand, as the functional group in the polymer containing a functional group, for example, glycidyl group, acryloyl group, methacryloyl group, hydroxyl group, carboxyl group, isocyanurate group, amino group, amide group, and the like may be listed. Among these, glycidyl group is especially preferable.

[0072] As the high molecular weight component containing a functional group, for example, meth(acrylic) copolymers containing functional groups such as glycidyl group, hydroxyl group, carboxyl group, and the like may be listed.

[0073] As such meth(acrylic) copolymers, for example, (meth)acryl ester copolymers, acrylic rubbers, and the like may be used. Among these, acrylic rubber is preferable. Acrylic rubbers are rubbers that contain acrylates as the main component, and mainly comprise copolymers of butyl acrylate and acrylonitrile and the like, or copolymers of ethyl acrylate and acrylonitrile and the like.

[0074] When the polymer contains glycidyl group as the functional group, the content of the glycidyl group-containing repeating units is preferably 0.5 to 5.0 wt%, and 0.8 to 5.0 wt% is especially preferable. Further preferable is 0.8 to 5.0 wt%. The

glycidyl group-containing repeating units refer to the monomer composing the (meth)acrylic copolymer that contains glycidyl group, and specifically refers to glycidyl acrylate or glycidyl methacrylate. When the amount of the glycidyl group-containing repeating units is in this range, adhesiveness is secured and gelation can be prevented.

[0075] As the monomer component of the above (meth)acrylic copolymer other than glycidyl acrylate and glycidyl methacrylate, for example, ethyl (meth)acrylate, butyl (meth)acrylate and the like may be listed. These may be used independently or as a combination of 2 or more types. Note that in the present invention, ethyl (meth)acrylate refers to ethyl acrylate and/or ethyl methacrylate. When using functional monomers in combination, the mixing ratio may be decided taking in consideration the glass transition temperature of the (meth)acrylic copolymer. When the glass transition temperature is -50°C or higher, it becomes excellent in film forming property and is preferable in that excessive tackiness at normal temperature can be suppressed. When the tackiness at normal temperature is excessive, the handling of the adhesive layer becomes difficult. More preferable is -20°C or higher, and further preferable is 0°C or higher. Further, when the glass transition temperature is 30°C or lower, it becomes excellent in the point of adhesiveness of the adhesive layer during die bonding. Further preferable is 20°C or lower.

[0076] When producing a high molecular weight component with functional monomers by polymerizing the above monomers, the method of polymerization is not particularly limited, and for example, methods such as pearl polymerization, solution polymerization, and the like may be applied. Pearl polymerization is especially preferable.

[0077] In the present invention, when the weight-average molecular weight of the high molecular weight component containing functional monomers is 100,000 or more, it becomes excellent in the point of film formation property. More preferable is 200,000 or more and further preferable is 500,000 or more. Further, when the weight-average molecular weight is adjusted to 2,000,000 or smaller, the heated fluidity of the adhesive layer during die bonding increases, and is thus superior. When the

heated fluidity of the adhesive layer during die bonding increases, the adhesion between the adhesive layer and the adherend becomes good and the adhesiveness can be enhanced. Further, the roughness on the adherend can be filled and voids can be controlled more easily. More preferable is 1,000,000 or smaller and further preferable is 800,000 or smaller. When the weight-average molecular weight is 500,000 or smaller, larger effects can be obtained.

[0078] Further, the thermal polymerization component, is not particularly limited, as long as it can be polymerized by heat, and compounds having functional groups such as glycidyl group, acryloyl group, methacryloyl group, hydroxyl group, carboxyl group, isocyanurate group, amino group, amide group and trigger materials may be listed. These may be used independently or as a combination of two or more types. However, from the point of heat resistance of the adhesive layer, it is preferable that a thermosetting resin, which is cured with heat and provides adhesive function, is added along with a curing agent and an accelerator. As the thermosetting resin, for example, epoxy resin, acrylic resin, silicone resin, phenol resin, thermosetting polyimide resin, polyurethane resin, melamine resin, urea resin, and the like may be listed. In particular, from the point of heat resistance, workability, and obtaining a highly reliable adhesive layer, it is most preferable to use epoxy resins.

[0079] The above epoxy resin is not particularly limited, as long as it can be cured to show adhesive function, and bifunctional epoxy resin such as bisphenol A-type epoxy, novolak-type epoxy resin such as phenol novolak-type epoxy resin and cresol novolak-type epoxy resin, may be used. Further, generally known epoxy resins such as multifunctional epoxy resin, glycidyl amine-type epoxy resin, heterocyclic epoxy resin, or alicyclic epoxy resin may be applied.

[0080] As the above bisphenol A-type epoxy resin, the EPIKOTE series by Mitsubishi Chemical Corporation (EPIKOTE 807, EPIKOTE 815, EPIKOTE 825, EPIKOTE 827, EPIKOTE 828, EPIKOTE 834, EPIKOTE 1001, EPIKOTE 1004, EPIKOTE 1007, EPIKOTE1009), DER-330, DER-301, DER-361 by the Dow Chemical Company, and YD8125, YDF8170 by Nippon Steel and Sumikin Chemical Corporation,

and the like may be listed. As the above phenol novolak-type epoxy resin, EPIKOTE 152, EPIKOTE154 by Mitsubishi Chemical Corporation, EPPN-201 by Nippon Kayaku Corporation, DEN-438 by Dow Chemical Company, and the like, as the above o-cresol novolak-type epoxy resin, EOCN-102S, EOCN-103S, EOCN-104S, EOCN-1012, EOCN-1025, EOCN-1027 by Nippon Kayaku Corporation and YDCN701, YDCN702, YDCN703, YDCN704, and the like by Nippon Steel and Sumikin Chemical Corporation, and the like may be listed. As the above multifunctional epoxy resin, Epon 1031S by Mitsubishi Chemical Corporation, Araldite 0163 by Ciba Specialty Chemicals, Denacol EX-611, EX-614, EX-614B, EX-622, EX-512, EX-521, EX-421, EX-411, EX-321 by Nagase ChemteX Corporation and the like may be listed. As the above amine-type epoxy resin, EPIKOTE 604 by Mitsubishi Chemical Corporation, YH-434 by Tohto Chemical Industry Co. Ltd., TETRAD-X and TETRAD-C by Mitsubishi Gas Chemical Corporation, ELM-120 by Sumitomo Chemical Co., Ltd. and the like may be listed.

As the heterocyclic epoxy resin Araldite PT810 by Ciba Specialty Chemicals, ERL4234, ERL4299, ERL4221, ERL4206 by UCC Corporation, and the like may be listed. These epoxy resins may be used independently or may be used as a combination of two or more types.

[0081] In order to cure the above thermosetting resin, an arbitrary additive may be added. As such additive, for example, a curing agent, a curing accelerator, a catalyst, and the like may be listed, and when adding a catalyst, a promoter may be used as required.

[0082] When epoxy resin is used as the above thermosetting resin, it is preferable to use an epoxy resin curing agent or a curing accelerator, and it is preferable to use them in combination. As the curing agent, for example, phenol resins, dicyandiamides, boron trifluoride complex compound, organic hydrazide compounds, amines, polyamide resin, imidazoles compounds, urea or thiourea compounds, polymercaptan compounds, polysulfide resins having a mercapto group on the terminal, acid anhydrides, as well as photo and thermal curing agents may be listed. These may be used independently or as a combination of two or more types.

Among these, as the boron trifluoride complex compound, boron trifluoride-amine complex with various amine compounds (preferably primary amine compounds) may be listed and as the organic hydrazide compounds, isophthalic acid dihydrazide may be listed.

[0083] As the phenol resin, for example, novolak-type phenol resins such as phenol novolak resin, phenol aralkyl resin, cresol novolak resin, tert-butyl phenol novolak resin, and nonylphenol resin, resol-type phenol resin, polyoxystyrene such as polyparaoxystyrene, and the like may be listed. Among these, phenol-type resins with at least two phenolic hydroxyl groups are preferable.

[0084] As the phenol-type resin having at least two phenolic hydroxyl groups, for example, phenol novolak resin, cresol novolak resin, t-butyl phenol novolak resin, dicyclopentadiene cresol novolak resin, dicyclopentadiene phenol novolak resin, xylylene modified phenol novolak resin, naphthol novolak resin, tris phenol novolak resin, tetrakis phenol novolak resin, bisphenol A novolak resin, poly-p-vinylphenol resin, phenol aralkyl resin, and the like may be listed. Further, among these phenol resins, phenol novolak resin and phenol aralkyl resin are especially preferable and can improve the connection reliability.

[0085] As the amine, linear aliphatic amines (diethylene triamine, triethylene tetramine, hexamethylene diamine, N,N-dimethylpropyl amine, benzyldimethyl amine, 2-(dimethyl amino)phenol, 2,4,6-tris(dimethylaminomethyl)phenol, m-xylene diamine, and the like), cyclic aliphatic amines (N-aminoethyl piperazine, bis(3-methyl-4-aminocyclohexyl) methane, bis(4-aminocyclohexyl) methane, menthene diamine, isophorone diamine, 1,3-bis(amino methyl)cyclohexane, and the like), heterocyclic amines (piperazine, N,N-dimethyl piperazine, triethylene diamine, melamine, guanamine, and the like), aromatic amines (meta-phenylene diamine, 4,4'-diaminodiphenyl methane, diamino,4,4'-diaminodiphenyl sulfone, and the like), polyamide resin (condensation product of dimer acid and polyamine, in which polyamide amine is preferable), imidazoles (2-phenyl-4,5-dihydroxymethyl imidazole, 2-methyl imidazole, 2,4-dimethyl imidazole, 2-n-heptadecyl imidazole, 1-cyanoethyl-

2-undecyl imidazolium trimellitate, epoxy-imidazole adduct, and the like), urea or thiourea compounds (N,N-dialkyl urea compounds, N,N-dialkyl thiourea compound, and the like), polymercaptan compounds, polysulfide resin having a mercapto group on its terminal, acid anhydride (tetrahydrophthalic anhydride, and the like), photo and ultraviolet ray curing agent (diphenyliodonium hexafluorophosphate, triphenylsulfonium hexafluorophosphate, and the like) may be exemplified.

[0086] The curing accelerator is not particularly limited as long as it can cure the thermosetting resin, and may be, for example, imidazoles, dicyandiamide derivatives, dicarboxylic acid dihydrazide, triphenylphosphine, tetraphenyl phosphonium tetraphenylborate, 2-ethyl-4-methylimidazole-tetraphenylborate, 1,8-diazabicyclo[5,4,0]undecene-7-tetraphenylborate, and the like may be listed.

As the imidazole, imidazole, 2-methylimidazole, 2-ethylimidazole, 2-ethyl-4-methylimidazole, 2-phenyl imidazole, 2-phenyl-4-methylimidazole, 1-benzyl-2-methylimidazole, 1-benzyl-2-ethylimidazole, 1-benzyl-2-ethyl-5-methylimidazole, 2-phenyl-4-methyl-5-hydroxydimethylimidazole, 2-phenyl-4,5-dihydroxy methylimidazole, and the like may be listed.

[0087] The amount of curing agent for the epoxy resin or the curing accelerator in the adhesive layer is not particularly limited, and the optimum amount differs with the type of curing agent or curing accelerator used.

[0088] The blending ratio of the epoxy resin and the phenol resin may preferably be, for example, to 1 equivalent of epoxy group in the above epoxy resin, 0.5 to 2.0 equivalents of hydroxyl groups in the phenol resin. More preferable is 0.8 to 1.2 equivalent. That is, when the blending ratio deviates from the above range, the curing reaction does not proceed sufficiently, and the property of the adhesive layer tends to deteriorate. For other thermosetting resins and curing agents, in one embodiment, for 100 parts by mass of the thermosetting resin, the curing agent is 0.5 to 20 parts by mass, and in another embodiment, the curing agent is 1 to 10 parts by mass. The content of the curing accelerator is preferably smaller than the content of the curing agent, and is preferably 0.001 to 1.5 parts by mass of curing accelerator in 100 parts by mass of the

thermosetting resin. More preferably, it is 0.01 to 0.95 parts by mass. By adjusting to the above-described range, the curing reaction can be supported sufficiently. The content of the catalyst is preferably 0.001 to 1.5 parts by mass in 100 parts by mass of the thermosetting resin. More preferably, it is 0.01 to 1.0 parts by mass.

[0089] Further, the adhesive layer 13 of the present invention may arbitrarily contain a filler, depending on its use. Such filler enables improvement in the dicing property and the handleability of the adhesive layer, adjusting the melt viscosity, adding thixotropic property, and further, adding thermal conductivity for the cured adhesive layer, and further, enables improvement of adhesiveness.

As the filler used in the present invention, inorganic fillers are preferable. The inorganic fillers are not particularly limited, and may be, for example, aluminum hydroxide, magnesium hydroxide, calcium carbonate, magnesium carbonate, calcium silicate, magnesium silicate, calcium oxide, magnesium oxide, alumina, aluminum nitride, aluminum borate whisker, boron nitride, crystalline silica, and amorphous silica, and antimony oxide may be used. Further, these may be used independently, or as a mixture of two or more types.

[0090] Further, among the above inorganic fillers, from the point of enhancement of thermal conductivity, the use of alumina, aluminum nitride, boron nitride, crystalline silica, amorphous silica, and the like is preferable. Further, from the point of adjusting melt viscosity and providing thixotropic property, the use of aluminum hydroxide, magnesium hydroxide, calcium carbonate, magnesium carbonate, calcium silicate, magnesium silicate, calcium oxide, magnesium oxide, alumina, crystalline silica, amorphous silica, and the like is preferable. Further, from the view point of enhancing dicing property, the use of alumina and silica is preferable.

[0091] When the content of filler is 30 mass% or more, excellent wire bonding property is obtained.

During wire bonding, it is preferable that the storage modulus of the adhesive layer, which adheres the chip to which the wire is attached after curing, is adjusted in the range of 20 to 1000 MPa at 170 °C. When the ratio of content of the filler is 75

mass% or less, the film formation property, the heated fluidity of the adhesive layer at die bonding becomes superior. When the heated fluidity of the adhesive layer at die bonding increases, the adhesion between the adhesive layer and the adherend is improved and the adhesiveness can be enhanced. Further, the roughness on the adherend can be filled and voids can be controlled more easily. More preferable is 70 mass% or less and further preferable is 60 mass% or less.

[0092] The adhesive layer of the present invention may contain two or more types of fillers with different average particle size as such filler. In such case, compared to the case where a single filler is used, it becomes easier to prevent the viscosity of the material mixture prior to film-formation from increasing when the ratio of content of the filler is high, or from decreasing when the ratio of content of the filler is low, and the film formation property is improved. Thus, the fluidity of the non-cured adhesive layer can be optimally controlled while excellent adhesion is obtained after curing of the adhesive layer.

[0093] Further, in the adhesive layer of the present invention, the average particle size of the filler is preferably 2.0 μm or smaller, and is more preferably 1.0 μm . When the average particle size of the filler is 2.0 μm or smaller, the film can easily be thinned. Here, a thin film refers to that with a thickness of 20 μm or smaller. Further, when it is 0.01 μm or larger, the dispersibility is improved.

Furthermore, from the view point of preventing the viscosity of the material mixture prior to film-formation from increasing or decreasing, optimally controlling the fluidity of the uncured adhesive layer, and enhancing the adhesive force of the adhesive layer after curing, it is preferable that the adhesive layer comprises a first filler with an average particle size in the range of 0.1 to 1.0 μm and a second filler with an average particle size of the primary particle in the range of 0.005 to 0.03 μm . It is preferable that the adhesive layer comprises a first filler with an average particle size in the range of 0.1 to 1.0 μm while 99% or more of the particles is dispersed in a particle size range of 0.1 to 1.0 μm , and a second filler with an average particle size of the primary particle in the range of 0.005 to 0.03 μm while 99% or more of the particles is dispersed in the

size range of 0.005 to 0.1 μm .

The average particle size in the present invention refers to the D50 value of the cumulative volume distribution curve, in which the 50 volume% particle measured by the laser diffraction method has a smaller diameter than this value. In the present invention, the average particle size or the D50 value is obtained by a laser diffraction method, performed using, for example, the Malvern Mastersizer 2000 of Malvern Instruments Ltd. In this technology, the size of the particle in a suspension is measured by the diffraction of laser ray, based on the application of either the Fraunhofer or the Mie theory. In the present invention, the Mie theory or the modified Mie theory for non-spherical particle is used, and the average particle size or D50 value is related to the scattering measurement at 0.02 to 135° against the incident laser ray.

[0094] In the present invention, in one embodiment, the total removable adhesive composition constituting the adhesive layer 13 may contain 10 to 40 mass% of a thermosetting resin with a weight-average molecular weight of 5000 to 200,000, 10 to 40 mass% of thermally polymerizable component, and 30 to 75 mass% of fillers. In this embodiment, the content of the filler may be 30 to 60 mass% or 40 to 60 mass%.

Further, the mass-average molecular weight of the thermosetting resin may be 5000 to 150,000 or 10,000 to 100,000.

In another embodiment, the total removable adhesive composition constituting the adhesive layer 13 may contain 10 to 20 mass% of a thermosetting resin with a weight-average molecular weight of 200,000 to 2,000,000, 20 to 50 mass% of thermally polymerizable component, and 30 to 75 mass% of fillers. In this embodiment, the content of the filler may be 30 to 60 mass% or 30 to 50 mass%. Further, the mass-average molecular weight of the thermosetting resin may be 200,000 to 1,000,000, or 200,000 to 800,000.

By adjusting the combination ratio, the storage modulus and fluidity of the adhesive layer 13 after curing can be optimized and the heat resistance tends to become sufficient.

[0095] In the semiconductor processing tape 10 of the present invention, the

adhesive layer 13 may be made into film form in advance (hereinafter referred to as adhesive film) and may be formed by directly or indirectly laminating onto the substrate film 11. The laminating temperature may be in the range of 10 to 100 °C and it is preferable to add a linear pressure of 0.01 to 10 N/m. Note that such adhesive film may be obtained by forming an adhesive layer 13 on a separator film, in which case, the separator film may be peeled after lamination, or may be used as a cover film for the semiconductor processing tape and peeled when being adhered to the wafer.

[0096] The aforementioned adhesive film may be laminated on the entirety of the removable adhesive layer 12, or the adhesive film may be cut into a shape that is in accordance to the wafer to be adhered beforehand (precut) and laminated onto the removable adhesive layer 12. When an adhesive film that is in accordance to the wafer is laminated, as shown in FIG. 3, the adhesive layer 13 exists on the part where the wafer W is adhered, but the adhesive layer 13 does not exist on the part where the ring frame 20 is adhered, and only the removable adhesive layer 12 exists. Since in general, the adhesive layer 13 is difficult to peel off from the adherend, by using an adhesive film that is precut, the ring frame 20 can be adhered with the removable adhesive layer 12, and when the tape is peeled after use, adhesive residues are less likely to remain on the ring frame 20.

[0097] <Use>

The semiconductor processing tape 10 of the present invention is used in a method of producing semiconductor device, which comprises at least an expand process of dividing the adhesive layer 13 by expansion. Thus, other processes and order of the processes are not particularly limited. For example, it can suitably be used in the following methods of producing semiconductor device (A) to (E).

[0098] Method of Producing Semiconductor Device (A)

A method of producing a semiconductor device, which comprises:

- (a) a process of adhering a surface protection tape on the front side of a wafer on which a circuit pattern has been formed;
- (b) a backgrinding process of grinding the back side of the wafer;

- (c) a process of adhering the adhesive layer of the semiconductor processing tape on the back side of the wafer, while heating the wafer;
- (d) a process of peeling the surface protection tape from the front side of the wafer;
- (e) a process of forming a modified region within the wafer through multiple-photon absorption by irradiating laser to a predetermined division part on the wafer;
- (f) an expand process of obtaining a plurality of chips with the adhesive layer attached thereto, by expanding the semiconductor processing tape to thereby divide the wafer and the adhesive layer of the semiconductor processing tape at the predetermined division part;
- (g) a process of maintaining space between the chips, by heat-shrinking a part of the expanded semiconductor processing tape that does not overlap with the chips, to thereby remove the slack that occur during the expand process; and
- (h) a pickup process of picking up the chip with the adhesive layer attached thereto from the removable adhesive layer of the semiconductor processing tape.

[0099] Method of Producing Semiconductor Device (B)

A method of producing a semiconductor device, which comprises:

- (a) a process of adhering a surface protection tape on the front side of a wafer on which a circuit pattern has been formed;
- (b) a backgrinding process of grinding the back side of the wafer;
- (c) a process of adhering the adhesive layer of the semiconductor processing tape on the back side of the wafer, while heating the wafer;
- (d) a process of peeling the surface protection tape from the front side of the wafer;
- (e) a process of dividing the wafer into chips by irradiating laser along a division line on the surface of the wafer;
- (f) an expand process of obtaining a plurality of chips with the adhesive layer attached thereto, by expanding the semiconductor processing tape to thereby divide the adhesive layer for each chip;
- (g) a process of maintaining space between the chips, by heat-shrinking a part of the expanded semiconductor processing tape that does not overlap with the chips, to thereby

remove the slack that occur during the expand process; and

(h) a pickup process of picking up the chip with the adhesive layer attached thereto from the removable adhesive layer of the semiconductor processing tape.

[0100] Method of Producing Semiconductor Device (C)

A method of producing a semiconductor device, which comprises:

- (a) a process of adhering a surface protection tape on the front side of a wafer on which a circuit pattern has been formed;
- (b) a backgrinding process of grinding the back side of the wafer;
- (c) a process of adhering the adhesive layer of the semiconductor processing tape on the back side of the wafer, while heating the wafer;
- (d) a process of peeling the surface protection tape from the front side of the wafer;
- (e) a process of dividing the wafer into chips along a division line by using a dicing blade;
- (f) an expand process of obtaining a plurality of chips with the adhesive layer attached thereto, by expanding the semiconductor processing tape to thereby divide the adhesive layer for each chip;
- (g) a process of maintaining space between the chips, by heat-shrinking a part of the expanded semiconductor processing tape that does not overlap with the chips, to thereby remove the slack that occur during the expand process; and
- (h) a pickup process of picking up the chip with the adhesive layer attached thereto from the removable adhesive layer of the semiconductor processing tape.

[0101] Method of Producing Semiconductor Device (D)

A method of producing a semiconductor device, which comprises:

- (a) a process of adhering a dicing tape on the back side of a wafer on which a circuit pattern has been formed and cutting the wafer to a depth that is smaller than the thickness of the wafer along a predetermined division line using a dicing blade;
- (b) a process of adhering a surface protection tape on the front side of the wafer
- (c) a backgrinding process of peeling off the dicing tape and grinding the back side of the wafer to thereby divide the wafer into chips;

- (d) a process of adhering the adhesive layer of the semiconductor processing tape on the back side of the wafer that is divided into chips, while heating the wafer;
- (e) a process of peeling the surface protection tape from the surface of the wafer that has been divided into the chips;
- (f) an expand process of obtaining a plurality of chips with the adhesive layer attached thereto, by expanding the semiconductor processing tape to thereby divide the adhesive layer for each chip;
- (g) a process of maintaining space between the chips by heat-shrinking a part of the expanded semiconductor processing tape that does not overlap with the chips, to thereby remove the slack that occur during the expand process; and
- (h) a pickup process of picking up the chip with the adhesive layer attached thereto from the removable adhesive layer of the semiconductor processing tape.

[0102] Method of Producing Semiconductor Device (E)

A method of producing a semiconductor device, which comprises:

- (a) a process of adhering a surface protection tape on the front side of the wafer;
- (b) a process of forming a modified region within the wafer through multiple-photon absorption by irradiating laser to a predetermined division part on the wafer;
- (c) a backgrinding process of grinding the back side of the wafer to thereby divide the wafer into chips;
- (d) a process of adhering the adhesive layer of the semiconductor processing tape on the back side of the wafer, while heating the wafer;
- (e) a process of peeling the surface protection tape from the front side of the wafer;
- (f) an expand process of obtaining a plurality of chips with the adhesive layer attached thereto, by expanding the semiconductor processing tape to thereby divide the wafer and the adhesive layer of the semiconductor processing tape at the division part;
- (g) a process of maintaining space between the chips by heat-shrinking a part of the expanded semiconductor processing tape that does not overlap with the chips, to thereby remove the slack that occur during the expand process; and
- (h) a pickup process of picking up the chip with the adhesive layer attached thereto

from the removable adhesive layer of the semiconductor processing tape.

[0103] <Method of Use>

The method of use of the tape when the semiconductor processing tape 10 of the present invention is applied to the aforementioned method of producing semiconductor device (A) will be describe with reference to FIG. 2 to FIG. 5. First, as shown in FIG. 2, on the front side of a wafer W, on which a circuit pattern has been formed, a surface protection film 14, which comprises a removable adhesive agent that contains an ultraviolet-curable component, for protecting the circuit pattern, is adhered, and a backgrinding process for grinding the back side of a wafer is performed.

[0104] After the backgrinding process, as shown in FIG. 3, the wafer W is mounted with the front side down on a heater table 25 of the wafer mounter, after which the semiconductor processing tape 10 is adhered onto the back side of the wafer W. Here, the semiconductor processing tape 10 is one with an adhesive film that has been cut in accordance with the shape of the wafer W that is to be adhered (precut) laminated thereto, and on the side that is adhered to the wafer W, the removable adhesive layer 12 is exposed around the area where the adhesive layer 13 is exposed. The part where the adhesive layer 13 of the semiconductor processing tape 10 is exposed is adhered together with the back side of the wafer W, and the part where the removable adhesive layer 12 around the adhesive layer 13 is exposed is adhered with the ring frame 20. Here, the heater table 25 is set to 70 to 80 °C, and heat laminating is performed. Note that, although a semiconductor processing tape 10, which comprises a removable adhesive tape 15 composed of a substrate film 11 and a removable adhesive layer 12 formed on the substrate film 11 and an adhesive layer 13 formed on top of the removable adhesive layer 12, was used in the present embodiment, it is also possible to use a removable adhesive tape and a film-form adhesive separately. In such case, first, a film-form adhesive is adhered to the back side of the wafer to form an adhesive layer, and the removable adhesive layer of the removable adhesive tape is adhered to the adhesive layer. Here, the removable adhesive tape 15 of the present invention is used as the removable adhesive tape.

[0105] Next, the wafer W with the semiconductor processing tape 10 adhered thereto is removed from the heater table 25, and mounted onto a suction table 26 with the semiconductor processing tape 10 side facing the bottom, as shown in FIG. 4. Then, using an energy ray source 27, for example, an ultraviolet ray of 1000 mJ/cm^2 is irradiated on the surface protection tape 14 from above the wafer W fixed on the suction table 26. The adhesiveness of the surface protection tape 14 to the wafer W is thus decrease, and the surface protection tape 14 is peeled from the surface of the wafer W.

[0106] Next, as shown in FIG. 5, laser is irradiated onto a predetermined division part of the wafer W, and a modified region 32 is formed within the wafer W through multiple-photon absorption.

[0107] Subsequently, as shown in FIG. 6(a), the semiconductor processing tape 10 with the wafer W and the ring frame 20 adhered thereto is mounted on the stage 21 of an expand machine with the substrate film 11 side on the bottom.

[0108] Next, as shown in FIG. 6(b), while the ring frame 20 is fixed, a hollow cylindrical push-up member 22 of the expand machine is raised to extend (expand) the semiconductor processing tape 10. The expand condition is, an expand speed of, for example, 5 to 500 mm/sec, and an expand amount (push-up amount) of, for example, 5 to 25 mm. By extending the semiconductor processing tape 10 in the direction of the diameter of the wafer W, the wafer W is divided into individual chip 34 units, beginning at the modified region 32. In this case, the adhesive layer 13 is not divided at the part where it is adhered to the back side of the wafer W, since stretching (deformation) by expansion is suppressed. However, at the part between each chip 34, the tensile strength by expansion of the tape is focused, and breakage occurs. Thus, as shown in FIG. 6 (c), the adhesive layer 13 is divided along with the wafer W. By such process, a plurality of chips 34 with the adhesive layer 13 attached thereto, are obtained.

[0109] Next, as shown in FIG. 7, the push-up member 22 is returned to its original position, and a process to remove the slack that occurred to the semiconductor processing tape 10 during the previous expand process, to thereby maintain the distance between each chip 34, is performed. In this process, for example, a heated air of about

90 to 120 °C is blown from a warm air nozzle 29 onto the ring-shaped heat-shrinking region 28, which is the area between the part where the chip 34 exists on the semiconductor processing tape 10 and the ring frame 20. The substrate film 11 is heat-shrunk, and the semiconductor processing tape is strained. Subsequently, energy ray-curing or heat-curing is performed to the removable adhesive layer 12, to thereby decrease the adhesiveness of the removable adhesive layer 12 to the adhesive layer 13, and the chips 34 are picked up.

[0110] Subsequently, energy ray-curing or heat-curing is performed to the removable adhesive layer 12, to thereby decrease the adhesiveness of the removable adhesive layer 12 to the adhesive layer 13, and the chips 34 are picked up.

Note that, as described previously, energy ray-curing treatment may be performed prior to expansion, and is favorable.

EXAMPLE

[0111] Next, in order to further clarify the effects of the present invention, Examples and Comparative Examples will be described in detail. However, the present invention is not limited to these Examples.

[0112] [Preparation of the Semiconductor processing tape]

(1) Preparation of the Substrate Film

<Substrate Film 1A>

Resin beads of zinc ionomer a (density 0.96 g/cm², zinc ion content 4 mass%, chlorine content less than 1 mass%, Vicat softening temperature 56 °C, melting point 86 °C), a ternary copolymer of ethylene-methacrylic acid-ethyl methacrylate (mass ratio 8:1:1) synthesized by radical polymerization, was melted at 140 °C. Using an extruder, a long film with a thickness of 100 μm was formed to obtain substrate film 1A.

<Substrate Film 2A>

Resin beads of zinc ionomer b (density 0.96 g/cm², zinc ion content 6 mass%, chlorine content less than 1 mass%, Vicat softening temperature 65 °C, melting point 88 °C), a binary copolymer of ethylene-methacrylic acid (mass ratio 7.5 : 2.5) synthesized

by radical polymerization, was melted at 140 °C. Using an extruder, a long film with a thickness of 100 µm was formed to obtain substrate film 2A.

<Substrate Film 3A>

Resin beads of zinc ionomer c (density 0.95 g/cm², zinc ion content 3 mass%, chlorine content less than 1 mass%, Vicat softening temperature 84 °C, melting point 102 °C), a binary copolymer of ethylene-methacrylic acid (mass ratio 9 : 1) synthesized by radical polymerization, was melted at 140 °C. Using an extruder, a long film with a thickness of 100 µm was formed to obtain substrate film 3A.

<Substrate Film 4A>

Resin beads of NOVATEC PP FW4B (polypropylene) of Japan Polychem Corporation (density 0.90 g/cm², Vicat softening temperature 96 °C, melting point 140 °C), was melted at 140 °C. Using an extruder, a long film with a thickness of 100 µm was formed to obtain substrate film 4A.

[0113] (2) Preparation of Removable Adhesive Composition

(Removable Adhesive 1B)

As an acrylic copolymer (A1) having a functional group, a copolymer containing 2-ethylhexyl acrylate, 2-hydroxyethyl acrylate, and acrylic acid, wherein the ratio of 2-ethylhexyl acrylate was 55 mol% and the mass-average molecular weight was 750,000 was prepared. Subsequently, 2-isocyanatoethyl methacrylate was added so that the iodine value became 25, and an acrylic copolymer (a-1) with a glass transition temperature of -50 °C, a hydroxyl value of 10 gKOH/g, and an acid value of 5 mgKOH/g was prepared.

A mixture of 100 parts by mass of acrylic copolymer (a-1), 3 parts by mass of P301-75E (product of Asahi Kasei Chemicals) as a polyisocyanate, and 3 parts by mass of Esacure KIP150 (product of Lamberti S.p.A) as a photopolymerization initiator, was dissolved in ethyl acetate and stirred to prepare removable adhesive composition 1B.

(Removable Adhesive 2B)

As acrylic copolymer (A2) having a functional group, a copolymer containing 2-ethylhexyl acrylate, 2-hydroxyethyl acrylate, and acrylic acid, wherein the ratio of

2-ethylhexyl acrylate was 55 mol% and the mass-average molecular weight was 750,000, was prepared. Subsequently, 2-isocyanatoethyl methacrylate was added so that the iodine value became 20, and an acrylic copolymer (a-2) with a glass transition temperature of -50 °C, a hydroxyl value of 15 gKOH/g, and an acid value of 5 mgKOH/g was prepared.

A mixture of 100 parts by mass of acrylic copolymer (a-2), 3 parts by mass of P301-75E (product of Asahi Kasei Chemicals) as a polyisocyanate, and 3 parts by mass of Esacure KIP150 (product of Lamberti S.p.A) as a photopolymerization initiator, was dissolved in ethyl acetate and stirred to prepare removable adhesive composition 2B. (Removable Adhesive 3B)

As acrylic copolymer (A3) having a functional group, a copolymer containing 2-ethylhexyl acrylate, 2-hydroxyethyl acrylate, and acrylic acid, wherein the ratio of 2-ethylhexyl acrylate was 55 mol% and the mass-average molecular weight was 750,000 was prepared. Subsequently, 2-isocyanatoethyl methacrylate was added so that the iodine value became 15, and an acrylic copolymer (a-3) with a glass transition temperature of -50 °C, a hydroxyl value of 20 gKOH/g, and an acid value of 5 mgKOH/g was prepared.

A mixture of 100 parts by mass of acrylic copolymer (a-3), 3 parts by mass of P301-75E (product of Asahi Kasei Chemicals) as a polyisocyanate, and 3 parts by mass of Esacure KIP150 (product of Lamberti S.p.A) as a photopolymerization initiator, was dissolved in ethyl acetate and stirred to prepare removable adhesive composition 3B. (Removable Adhesive 4B)

As acrylic copolymer (A4) having a functional group, a copolymer containing 2-ethylhexyl acrylate, 2-hydroxyethyl acrylate, and acrylic acid, wherein the ratio of 2-ethylhexyl acrylate was 55 mol% and the mass-average molecular weight was 750,000, was prepared. Subsequently, 2-isocyanatoethyl methacrylate was added so that the iodine value became 5, and an acrylic copolymer (a-4) with a glass transition temperature of -50 °C, a hydroxyl value of 30 mgKOH/g, and an acid value of 5 mgKOH/g was prepared.

A mixture of 100 parts by mass of acrylic copolymer (a-4), 3 parts by mass of P301-75E (product of Asahi Kasei Chemicals) as a polyisocyanate, and 3 parts by mass of Esacure KIP150 (product of Lamberti S.p.A) as a photopolymerization initiator, was dissolved in ethyl acetate and stirred to prepare removable adhesive composition 4B.

[0114] (3) Preparation of Removable Adhesive Sheet

The removable adhesive compositions 1B to 4B were applied to a release liner composed of polyethylene-terephthalate film subjected to a release treatment, so that the thickness after drying became 10 μm , and dried at 110 °C for 2 minutes.

Subsequently, these were adhered to the substrate films of 1A to 4B, to provide removable adhesive sheets with removable adhesive layers formed on the substrate film.

[0115] (4) Preparation of Adhesive Composition

To a composition consisting of 50 parts by mass of epoxy resin "1002" (product of Mitsubishi Chemical., solid bisphenol A-type epoxy resin, epoxy equivalent 600), 100 parts by mass of a epoxy resin "806" (product of Mitsubishi Chemical., bisphenol F-type epoxy resin, epoxy equivalent 160, specific gravity 1.20), 5 parts by mass of "Dyhard 100SF" (product of Degussa AG, trade name dicyandiamide) as a curing agent, and 5 parts by mass of a silica filler "Aerosil R972" (manufactured by Nippon Aerosil Co., Ltd., trade name, average particle size 0.016 μm), MEK was added, mixed and agitated to prepare a uniform composition.

Then, 100 parts by mass of phenoxy resin "PKHH" (product of INCHEM, trade name, mass-average molecular weight 52,000, glass transition temperature 92 °C), 0.4 parts by mass of "KBM-802" (product of Shin-Etsu Silicone, trade name, mercaptopropyl trimethoxy silane) as a coupling agent, and 0.5 parts by mass of "CUREZOL 2PHZ-PW" (product of Shikoku Chemicals Corporation, trade name, 2-phenyl-4,5-dihydroxymethyl imidazole, decomposition temperature 230 °C) were added, mixed and agitated until uniform. Further, this mixture was filtrated through a filter of 100 mesh and vacuum deaerated to obtain a varnish.

[0116] (5) Preparation of Adhesive Film

Next, to a release liner composed of polyethylene-terephthalate subjected to a

release treatment, the above adhesive composition was applied, so that the thickness after drying became 20 μm , and was dried at 130 °C for 3 minutes, to prepare an adhesive film with an adhesive layer formed on a release liner.

[0117] (6) Preparation of Semiconductor Processing Tape

The removable adhesive sheet was cut into a shape similar to that shown in FIG. 3 etc., which enables it to be adhered to the ring frame so that the opening can be covered. Further, the adhesive film was cut into a shape similar to that shown in FIG. 3 etc., so that it can cover the back side of the wafer. Moreover, the removable adhesive layer side of the removable adhesive sheet and the adhesive layer side of the adhesive film were adhered together so that the removable adhesive layer 12 was exposed around the adhesive film, as shown in FIG. 3 etc., to prepare a semiconductor processing tape.

[0118] <Examples 1 to 5, Comparative Examples 1, 3 to 5>

A surface protection tape was adhered on the front side of a wafer on which a circuit pattern was formed;

a modified region was formed within the wafer through multiple-photon absorption by irradiating laser to a predetermined division part on the wafer;

a backgrinding process of grinding the back side of the wafer was performed;

the adhesive layer of the semiconductor processing tape was adhered on the back side of the wafer, while heating the wafer at a temperature of 70 to 80 °C;

the surface protection tape was peeled from the surface of the wafer;

the semiconductor processing tape was subjected to ultraviolet irradiation at an output of 200 mJ/cm^2 ;

the semiconductor processing tape was expanded to thereby divide the wafer and the adhesive layer of the semiconductor processing tape along the division line, to obtain a plurality of chips with the adhesive layer attached thereto;

the part of the semiconductor processing tape that does not overlap with the chips (the ring-formed region between the region where the chips exist and the ring frame) was heated at 100 °C and shrunk, to thereby remove the slack that occurred

during the expand process, and physical properties of the semiconductor processing tape subjected to a process of maintaining the interval between the chips were evaluated as follows. Note that the chip size was 5 mm x 5mm.

[0119] <Comparative Example 2>

Other than not performing the ultraviolet irradiation treatment, the semiconductor processing tape was subjected to the same processes as those of Examples 1 to 5 and Comparative Examples 1, 3 to 5, and evaluated for the following physical properties.

[0120] [Table 1]

	Substrate	Removable Adhesive
Example 1	1A	2B
Example 2	1A	3B
Example 3	1A	4B
Example 4	2A	3B
Example 5	3A	4B
Comparative Example 1	1A	1B
Comparative Example 2	1A	2B
Comparative Example 3	2A	2B
Comparative Example 4	3A	3B
Comparative Example 5	4A	4B

[0121] <Measurement of Stress>

For the removable adhesive tape in the process of dividing the adhesive layer by expansion, a tensile test was performed, and the stress of the substrate alone and the stress of the removable adhesive tape were measured when the tensile elongation was 10%.

Note that the "stress of the removable adhesive tape" refers to the stress of the semiconductor processing tape 10, collected at the expansion process in the method for producing the semiconductor device.

Further, the "stress of the substrate alone" refers to the stress of the substrate film 11 by itself prior to arranging the removable adhesive layer on the substrate film 11.

[0122] <Evaluation of Pickup Property>

A process of picking up semiconductor chips from the removable adhesive layer of the semiconductor processing tape was performed to evaluate the pickup property.

Specifically, a pickup test was performed for 1000 arbitrary chips, using a dice picker machine (manufactured by Canon Machinery Inc., trade name CAP-300II), and those for which the adhesive layer remained after peeling from the removable adhesive layer was evaluated as successful pickup, and the pickup success rate was calculated to thereby evaluate the pickup property.

Those with a pickup success rate of 100% were marked "◎" for Excellent Product.

Those with a pickup success rate of 98% or more were marked "○" for Good Product.

Those with a pickup success rate of 95% or more to less than 98% were marked "△" for Tolerable Products.

Those with a pickup success rate of less than 95% were marked "X" for Inferior Product.

[0123] <Evaluation Kerf Width Evenness>

In a wafer of 12 inches, the kerf width in the longitudinal direction and width direction at the center of effective chips (5 mm x 5 mm) were measured, and the smaller values were evaluated as follows:

For 50 μm or more, "◎";

For 30 μm or more to less than 50 μm , "○";

For 15 μm or more to less than 30 μm , "△";

For less than 15 μm , "X".

[0124] Results of the stress, evaluation of kerf width, and evaluation of pickup

properties are shown in Table 2.

[0125] [Table 2]

	Example 1	Example 2	Example 3	Example 4	Example 5	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4	Comparative Example 5
Removable Adhesive Tape	5.1	4.6	3.9	5.2	5.7	5.9	5.8	6.1	6.5	6.1
Substrate Alone	5.3	5.3	5.3	5.8	6.3	5.3	5.3	5.8	6.3	5.8
Removable Adhesive Tape/Substrate Alone	0.96	0.87	0.74	0.9	0.9	1.11	1.09	1.05	1.03	1.05
Kerf Width Evaluation	◎	◎	◎	○	△	×	×	×	×	×
Pickup Property Evaluation	◎	◎	△	◎	△	×	×	×	×	×

[0126] <Evaluation Results>

As shown in Table 2, in Examples 1 to 5, which fulfill the condition of stress of removable adhesive tape/stress of substrate alone = 1, the kerf width expanded sufficiently and evenly, and showed excellent pickup properties unseen in prior art.

On the other hand, in Comparative Examples 1 to 4, which did not fulfill the above condition, the kerf width was narrow or uneven, and the pickup property was evaluated as being inferior.

DESCRIPTION OF NOTATIONS

[0127] 10: semiconductor processing tape

11: substrate film

12: removable adhesive layer

13: adhesive layer

14: surface protection tape

15: supporting tape

20: ring frame

21: stage

22: push-up member

25: heater table

26: suction table

27: ultraviolet (energy ray) source

28: heat shrinking region

29: warm air nozzle

32: modified region

34: chip

Claims

1. A semiconductor processing tape, which comprises a removable adhesive tape that is provided with a substrate film and a removable adhesive layer formed on at least one side of the substrate film, wherein,
in the process of fragmenting the adhesive by expansion, when the tensile elongation of the removable adhesive tape according to the method of JIS7162 is 10%, the relationship between the stress of the substrate alone and the stress of the removable adhesive tape, is:
$$\text{stress on removable adhesive tape} / \text{stress on substrate alone} = 1 \text{ or less.}$$

2. The semiconductor processing tape according to Claim 1, which is utilized in a method for producing a semiconductor device, which comprises:

- (a) a process of adhering a surface protection tape on the front side of a wafer on which a circuit pattern has been formed;
- (b) a backgrinding process of grinding the back side of the wafer;
- (c) a process of adhering the adhesive layer of the semiconductor processing tape on the back side of the wafer, while heating the wafer;
- (d) a process of peeling the surface protection tape from the front side of the wafer;
- (e) a process of forming a modified region within the wafer through multiple-photon absorption by irradiating laser to a predetermined division part on the wafer;
- (f) an expand process of obtaining a plurality of chips with the adhesive layer attached thereto, by expanding the semiconductor processing tape to thereby divide the wafer and the adhesive layer of the semiconductor processing tape at the predetermined division part;
- (g) a process of maintaining space between the chips, by heat-shrinking a part of the expanded semiconductor processing tape that does not overlap with the chips, to thereby remove the slack that occur during the expand process; and
- (h) a pickup process of picking up the chip with the adhesive layer attached thereto

from the removable adhesive layer of the semiconductor processing tape.

3. The semiconductor processing tape according to Claim 1, which is utilized in a method for producing a semiconductor device, which comprises:

- (a) a process of adhering a surface protection tape on the front side of a wafer on which a circuit pattern has been formed;
- (b) a backgrinding process of grinding the back side of the wafer;
- (c) a process of adhering the adhesive layer of the semiconductor processing tape on the back side of the wafer, while heating the wafer;
- (d) a process of peeling the surface protection tape from the front side of the wafer;
- (e) a process of dividing the wafer into chips by irradiating laser along a division line on the front side of the wafer;
- (f) an expand process of obtaining a plurality of chips with the adhesive layer attached thereto, by expanding the semiconductor processing tape to thereby divide the adhesive layer for each chip;
- (g) a process of maintaining space between the chips, by heat-shrinking a part of the expanded semiconductor processing tape that does not overlap with the chips, to thereby remove the slack that occur during the expand process; and
- (h) a pickup process of picking up the chip with the adhesive layer attached thereto from the removable adhesive layer of the semiconductor processing tape.

4. The semiconductor processing tape according to Claim 1, which is utilized in a method for producing a semiconductor device, which comprises:

- (a) a process of adhering a surface protection tape on the front side of a wafer on which a circuit pattern has been formed;
- (b) a backgrinding process of grinding the back side of the wafer;
- (c) a process of adhering the adhesive layer of the semiconductor processing tape on the back side of the wafer, while heating the wafer;
- (d) a process of peeling the surface protection tape from the wafer surface;

- (e) a process of dividing the wafer into chips by cutting along a division line using a dicing blade;
- (f) an expand process of obtaining a plurality of chips with the adhesive layer attached thereto, by expanding the semiconductor processing tape to thereby divide the adhesive layer for each chip;
- (g) a process of maintaining space between the chips by heat-shrinking a part of the expanded semiconductor processing tape that does not overlap with the chips, to thereby remove the slack that occur during the expand process; and
- (h) a pickup process of picking up the chip with the adhesive layer attached thereto from the removable adhesive layer of the semiconductor processing tape.

5. The semiconductor processing tape according to Claim 1, which is utilized in a method for producing a semiconductor device, which comprises:

- (a) a process of cutting a wafer on which a circuit pattern has been formed up to a depth that is smaller than the thickness of the wafer along a predetermined division line using a dicing blade;
- (b) a process of adhering a surface protection tape on the front side of the wafer
- (c) a backgrinding process of grinding the back side of the wafer to thereby divide the wafer into chips;
- (d) a process of adhering the adhesive layer of the semiconductor processing tape on the back side of the wafer that is divided into chips, while heating the wafer;
- (e) a process of peeling the surface protection tape from the front side of the wafer that has been divided into the chips;
- (f) an expand process of obtaining a plurality of chips with the adhesive layer attached thereto, by expanding the semiconductor processing tape to thereby divide the adhesive layer for each chip;
- (g) a process of maintaining space between the chips by heat-shrinking a part of the expanded semiconductor processing tape that does not overlap with the chips, to thereby remove the slack that occur during the expand process; and

(h) a pickup process of picking up the chip with the adhesive layer attached thereto from the removable adhesive layer of the semiconductor processing tape.

6. The semiconductor processing tape according to Claim 1, which is utilized in a method for producing a semiconductor device, which comprises:

- (a) a process of adhering a surface protection tape on the front side of a wafer on which a circuit pattern has been formed;
- (b) a process of forming a modified region within the wafer through multiple-photon absorption by irradiating laser to a predetermined division part on the wafer;
- (c) a backgrinding process of grinding the back side of the wafer;
- (d) a process of adhering the adhesive layer of the semiconductor processing tape on the back side of the wafer, while heating the wafer;
- (e) a process of peeling the surface protection tape from the front side of the wafer;
- (f) an expand process of obtaining a plurality of chips with the adhesive layer attached thereto, by expanding the semiconductor processing tape to thereby divide the wafer and the adhesive layer of the semiconductor processing tape at the division part;
- (g) a process of maintaining space between the chips, by heat-shrinking a part of the expanded semiconductor processing tape that does not overlap with the chips, to thereby remove the slack that occur during the expand process; and
- (h) a pickup process of picking up the chip with the adhesive layer attached thereto from the removable adhesive layer of the semiconductor processing tape.

7. A semiconductor device that utilizes the semiconductor processing tape according to any one of Claims 1 to 6.