DESCRIPTION

Title of Invention: SEMICONDUCTOR DEVICE PRODUCTION METHOD AND DICING-DIE BONDING INTEGRATED FILM

Technical Field

[0001] The present disclosure relates to a method for producing a semiconductor device and a dicing/die-bonding integrated film.

Background Art

[0002] During a process of singulating a semiconductor wafer, a dicing/die-bonding integrated film, in which a dicing film having a base film and a pressure-sensitive adhesive layer for immobilizing the semiconductor wafer is integrated with a die-bonding film for adhering to a substrate or another semiconductor chip, may be used for producing a semiconductor device (semiconductor package) (see, for example, Patent Literatures 1 and 2). The die-bonding film constituting the dicing/die-bonding integrated film generally often has a thickness of about several tens of μm.

[0003] In recent years, as methods for singulating a semiconductor wafer, the SDBG (Stealth Dicing Before Grinding) method, the DBG (Dicing Before Grinding) method, and the like have been put into practical use (see, for example, Patent Literature 3). The SDBG method is a method of forming a modified region inside a semiconductor wafer by laser beam irradiation, then grinding (polishing) the semiconductor wafer from the back surface side, and cleaving the semiconductor wafer using the modified region as a division starting point to singulate it into a plurality of semiconductor chips. The DBG method is a method of forming grooves of a predetermined depth on the surface of a semiconductor wafer with a

dicing blade or the like, and then grinding (polishing) the semiconductor wafer from the back surface side up to the grooves to singulate it into a plurality of semiconductor chips. The die-bonding film of a dicing/die-bonding integrated film is attached to the plurality of semiconductor chips singulated by these methods under a heating condition. Subsequently, by expanding the dicing film under cooling conditions (cooling expansion), the die-bonding film is singulated, and a semiconductor chip with a die-bonding film piece, which has the semiconductor chip and a die-bonding film piece obtained by singulating the die-bonding film, is obtained. Subsequently, by picking up the obtained semiconductor chip with a die-bonding film piece and mounting it on a substrate or another semiconductor chip, a semiconductor device can be produced.

Citation List

Patent Literature

[0004] Patent Literature 1: JP 2019-175958 A

Patent Literature 2: WO 2018/105613 A1

Patent Literature 3: JP 2022-179420 A

Summary of Invention

Technical Problem

[0005] By the way, with the increase in the number of stacked semiconductor chips and the thinning of semiconductor chips in semiconductor devices, the application of an extremely thin die-bonding film (for example, 20 μm or less) is desired. However, according to studies by the present inventors, in a method for producing a semiconductor device, the method including attaching the die-bonding film of a dicing/die-bonding integrated film to a plurality of semiconductor chips

under heating conditions (e.g., 60°C or higher), and singulating the die-bonding film by expanding the dicing film under cooling conditions (e.g., 0°C or lower) to produce a semiconductor chip with a die-bonding film piece, it has been found that when an extremely thin die-bonding film is applied as the die-bonding film of the dicing/die-bonding integrated film, the die-bonding film tends to be difficult to separate in the cooling expansion. If the die-bonding film is not easily separated, it becomes difficult to pick up the semiconductor chip with a die-bonding film piece, and there is a risk that the yield may decrease in the production of semiconductor devices.

[0006] Therefore, a main object of the present disclosure is to improve the separability upon cooling of a die-bonding film having a thickness of 20 μm or less in a predetermined method for producing a semiconductor device.

Solution to Problem

[0007] Fig. 4 is a plan view schematically showing a state after a semiconductor wafer has been singulated. Fig. 4 shows that a plurality of semiconductor chips C, which are singulated from a semiconductor wafer, exist on a die-bonding film 1. The state after the semiconductor wafer has been singulated can be divided into end portions in the MD direction (Machine Direction, a direction parallel to the longitudinal direction (flow direction) in the original roll providing the base film) of the semiconductor wafer (regions represented by X in Fig. 4) and a central portion other than those (region represented by Y in Fig. 4). The end portions of the semiconductor wafer can be defined as the regions from both ends in the MD direction of the semiconductor wafer to the dicing lines at a

predetermined position (for example, the fifth line), respectively. The central portion of the semiconductor wafer can be defined as the region other than the end portions of the semiconductor wafer.

[0008] When the present inventors studied the separability of the die-bonding film upon cooling, they found that in a dicing/die-bonding integrated film, if the tensile stress of the dicing film under cooling conditions is too low, the separability of the die-bonding film upon cooling tends to decrease, particularly in the central portion of the semiconductor wafer (see Fig. 4). When the present inventors conducted further studies, they found that the kerf width (gap between semiconductor chips) between the semiconductor chips after the die-bonding film of the dicing/die-bonding integrated film is attached to a plurality of semiconductor chips under heating conditions correlates with the separability of the die-bonding film upon cooling, and that if the kerf width is too wide, the stress during cooling expansion is dispersed, and the separability of the die-bonding film upon cooling tends to decrease, particularly at the end portions of the semiconductor wafer (see Fig. 4). When the present inventors investigated in detail the cause of the widening of the kerf width, they found that it occurs because the dicing film thermally shrinks due to the heating when attaching the die-bonding film of the dicing/die-bonding integrated film to the plurality of semiconductor chips, and this thermal shrinkage pulls the die-bonding film in the direction of expansion.

[0009] Based on the above findings, the present inventors focused on the tensile stress of the dicing film under cooling conditions and the thermal shrinkage rate under heating conditions in a dicing/die-bonding integrated film, and found that by adopting a dicing film in which these are within

predetermined ranges, the above problem can be solved, and have completed the invention of the present disclosure.

[0010] The present disclosure includes [1] to [5].

[1] A method for producing a semiconductor device, the method including:

(A) attaching the die-bonding film of a dicing/die-bonding integrated film, the integrated film including a dicing film having a base film and a pressure-sensitive adhesive layer provided on the base film, and a die-bonding film provided on the pressure-sensitive adhesive layer, to a plurality of semiconductor chips obtained by singulating a semiconductor wafer, under a heating condition; and

(B) singulating the die-bonding film by expanding the dicing film under a cooling condition, thereby producing a semiconductor chip with a die-bonding film piece, which includes the semiconductor chip and a die-bonding film piece obtained by singulating the die-bonding film,

wherein

a thickness of the die-bonding film is 20 μm or less, and

a tensile stress at 20% elongation at 0°C in a tensile test of the dicing film is 15 MPa or more, and a thermal shrinkage rate at 70°C in thermomechanical analysis of the dicing film is 5% or less.

[2] The method according to [1], wherein a maximum thermal shrinkage rate of the dicing film between 80°C and 140°C in thermomechanical analysis is 10% or more.

[3] The method according to [1] or [2], wherein, in (A), the method for singulating the semiconductor wafer is a stealth dicing method or a half-cut dicing method.

[4] A dicing/die-bonding integrated film including:

a dicing film having a base film and a pressure-sensitive adhesive layer provided on the base film; and

a die-bonding film provided on the pressure-sensitive adhesive layer,

wherein

a thickness of the die-bonding film is 20 μm or less, and

a tensile stress at 20% elongation at 0°C in a tensile test of the dicing film is 15 MPa or more, and a thermal shrinkage rate at 70°C in thermomechanical analysis of the dicing film is 5% or less.

[5] The dicing/die-bonding integrated film according to [4], wherein a maximum thermal shrinkage rate of the dicing film between 80°C and 140°C in thermomechanical analysis is 10% or more.

Advantageous Effects of Invention

[0011] According to the present disclosure, it is possible to improve the separability upon cooling of a die-bonding film having a thickness of 20 μm or less in a predetermined method for producing a semiconductor device.

Brief Description of Drawings

[0012] Fig. 1 is a schematic cross-sectional view showing an embodiment of a dicing/die-bonding integrated film.

Fig. 2 is a schematic cross-sectional view showing a method for producing a semiconductor device, and Fig. 2(a), Fig. 2(b), and Fig. 2(c) are schematic cross-sectional views showing each step.

Fig. 3 is a schematic cross-sectional view showing a method for producing a semiconductor device, and Fig. 3(a) and Fig. 3(b) are

schematic cross-sectional views showing each step.

Fig. 4 is a schematic top view showing a state after a semiconductor wafer has been singulated.

Fig. 5 is a top view showing measurement points in the measurement of kerf width after attachment in the examples, where Fig. 5(a) is a top view showing measurement points at an end portion of the semiconductor wafer, and Fig. 5(b) is a top view showing measurement points at a central portion of the semiconductor wafer.

Fig. 6 is a top view showing measurement points in the measurement of kerf width after thermal shrinkage in the examples.

Description of Embodiments

[0013] Hereinafter, embodiments of the present disclosure will be described with appropriate reference to the drawings. However, the present disclosure is not limited to the following embodiments. The constituent elements (including steps, etc.) in the following embodiments are not essential unless otherwise specified. The size of the constituent elements in each drawing is conceptual, and the relative relationship of the sizes between the constituent elements is not limited to that shown in each drawing.

[0014] The same applies to the numerical values and their ranges in this specification, and they do not limit the present disclosure. A numerical range indicated using "to" in this specification indicates a range including the numerical values described before and after "to" as the minimum and maximum values, respectively. In the numerical ranges described in stages in this specification, the upper limit value or lower limit value described in one numerical range may be replaced with the upper limit value or

lower limit value of another staged numerical range. Further, in the numerical ranges described in this specification, the upper limit value or lower limit value of the numerical range may be replaced with the value shown in the examples.

[0015] In this specification, "(meth)acrylate" means at least one of acrylate and the corresponding methacrylate. The same applies to other similar expressions such as "(meth)acryloyl". Also, "(poly)" means both with and without the prefix "poly". Also, "A or B" means that either A or B may be included, and both may be included. Further, the materials exemplified below may be used alone or in combination of two or more, unless otherwise specified. The content of each component in a composition means the total amount of the plurality of substances corresponding to each component present in the composition, unless otherwise specified.

[0016] [Dicing/die-bonding integrated film]

Fig. 1 is a schematic cross-sectional view showing an embodiment of a dicing/die-bonding integrated film. The dicing/die-bonding integrated film 10 shown in Fig. 1 includes a die-bonding film 1 (hereinafter, may be referred to as an "adhesive layer") and a dicing film 5 having a pressure-sensitive adhesive layer 2 attached to the die-bonding film 1. The dicing film 5 has a base film 3 and a pressure-sensitive adhesive layer 2 provided on the base film 3.

[0017] The die-bonding film 1 is an adhesive film for adhering a semiconductor chip to a substrate or another semiconductor chip, and may also be referred to as a die attach film (DAF). The die-bonding film 1 has, for example, a circular principal surface that covers the entire principal surface of a semiconductor wafer.

[0018] The die-bonding film 1 (adhesive layer) has a thickness of 20 μm or less. A thickness of the die-bonding film 1 of 20 μm or less is advantageous, for example, for the production of a thin semiconductor package having a multilayer semiconductor chip. The thickness of the die-bonding film 1 may be, for example, 18 μm or less, 16 μm or less, 14 μm or less, 12 μm or less, or 10 μm or less, and may be 1 μm or more, 2 μm or more, 3 μm or more, 4 μm or more, or 5 μm or more.

[0019] The die-bonding film 1 may be a film formed from an adhesive commonly used for adhering semiconductor chips. The die-bonding film 1 may be a thermosetting adhesive. The thermosetting adhesive constituting the die-bonding film 1 includes, for example, a thermosetting component and a high-molecular-weight resin component (elastomer).

[0020] The thermosetting component is a compound (resin) having a reactive group that forms a crosslinked structure by self-polymerization and/or reaction with a curing agent. The thermosetting component may, for example, include an epoxy resin, and in addition to the epoxy resin, may include a phenolic resin that acts as a curing agent for the epoxy resin. The content of the thermosetting component may be 5 to 30 parts by mass with respect to 100 parts by mass of the total amount of the die-bonding film.

[0021] The high-molecular-weight resin component (elastomer) may include at least one resin selected from the group consisting of, for example, acrylic rubber, polyimide, and phenoxy resin, and may include acrylic rubber. The high-molecular-weight resin component may have a reactive group such as an epoxy group. The weight-average molecular weight (in terms of standard polystyrene by GPC method) of the high-

molecular-weight resin component may be 100,000 to 3,000,000. The content of the high-molecular-weight resin component may be 30 to 80 parts by mass with respect to 100 parts by mass of the total amount of the die-bonding film.

[0022] The thermosetting adhesive may contain other components as necessary. Examples of other components include a curing accelerator that promotes the reaction between the epoxy resin and the phenolic resin, a coupling agent (e.g., a silane coupling agent), and an inorganic filler (e.g., silica).

[0023] The dicing film 5 has a base film 3 and a pressure-sensitive adhesive layer 2 provided on the base film 3. The base film 3 has, for example, a rectangular principal surface. The pressure-sensitive adhesive layer 2 has a principal surface 2a in contact with the base film 3 and a principal surface 2b in contact with the die-bonding film 1. The principal surfaces 2a, 2b of the pressure-sensitive adhesive layer 2 may be circular surfaces of a size that covers the entire principal surface of the die-bonding film 1.

[0024] The tensile stress of the dicing film 5 at 20% elongation at 0°C in a tensile test is 15 MPa or more. When the tensile stress is 15 MPa or more, the separability of the die-bonding film upon cooling can be improved, particularly in the central portion of the semiconductor wafer. The tensile stress may be 16 MPa or more, or 17 MPa or more. The upper limit of the tensile stress is not particularly limited, but may be, for example, 30 MPa or less, or 25 MPa or less.

[0025] In this specification, the tensile stress of the dicing film at 20% elongation at 0°C in a tensile test means a value measured in accordance

with JIS K 7161-1:2014. More specifically, using a tensile testing machine (e.g., Tensilon (RTF-1250-HS-PL, manufactured by A&D Company, Limited)), a tensile test is performed on the following sample under the measurement conditions to obtain an S-S curve (stress-strain curve). In the obtained S-S curve, the stress value in the MD direction (flow direction) of the base film at 20% elongation is read, and this can be taken as the value of the tensile stress.

(Measurement Conditions)

Sample: Dumbbell-shaped No. 1 test piece

Chuck distance: 40 mm

Temperature condition: 0°C ± 2°C

Tensile speed: 300 mm/min

[0026] The tensile stress can be increased, for example, by using an ethylene copolymer, an ionomer resin, or the like as the main component of the base film. Also, the tensile stress can be increased by mixing an inorganic filler or the like into the base film.

[0027] The thermal shrinkage rate of the dicing film 5 at 70°C in thermomechanical analysis (TMA) is 5% or less. When the thermal shrinkage rate is 5% or less, it is possible to suppress the kerf width between semiconductor chips from becoming too wide after the die-bonding film of the dicing/die-bonding integrated film is attached to a plurality of semiconductor chips under a heating condition, and as a result, the separability of the die-bonding film upon cooling can be improved, particularly at the end portions of the semiconductor wafer. The thermal shrinkage rate may be 4.5% or less, or 4% or less. The lower limit of the thermal shrinkage rate is not particularly limited, but may be, for example,

1% or more, or 2% or more.

[0028] The maximum thermal shrinkage rate of the dicing film 5 between 80°C and 140°C in thermomechanical analysis (TMA) may be 10% or more. When the maximum thermal shrinkage rate is 10% or more, the kerf width after thermal shrinkage of the dicing film can be secured even more favorably. The maximum thermal shrinkage rate may be 11% or more, 12% or more, or 13% or more, and may be 40% or less, 35% or less, or 30% or less.

[0029] In this specification, the thermal shrinkage rate at 70°C and the maximum thermal shrinkage rate between 80°C and 140°C of the dicing film in thermomechanical analysis (TMA) can be determined, for example, by the following method. First, a test specimen having a size of 25 mm in length and 4 mm in width is cut out from the dicing film. The cutting direction is such that the MD direction of the dicing film is 25 mm in length, and the TD direction (Transverse Direction, a direction orthogonal to the MD direction (perpendicular direction)) is 4 mm in width. Next, using a thermomechanical analyzer (e.g., TMA7100, manufactured by Hitachi High-Tech Corporation), the thermal shrinkage amount of the dicing film in the MD direction is measured for the test specimen under the following measurement conditions. The value of the thermal shrinkage amount at 70°C and the maximum value of the thermal shrinkage amount between 80°C and 140°C are read, respectively, and by dividing by the initial length of the test specimen measured with the thermomechanical analyzer, the respective thermal shrinkage rates can be obtained.

(Measurement Conditions)

Chuck distance: 10 mm (width 4 mm)

Load: 0 mN

Temperature range: 30 to 180°C

Heating rate: 5°C/min

[0030] The thermal shrinkage rate at 70°C can be decreased, for example, by using polyethylene, polypropylene, or the like as a component of the base film. Also, the thermal shrinkage rate can be decreased by mixing a polyamide resin or the like into the base film. Furthermore, the thermal shrinkage rate can also be decreased by lowering the winding tension during the production of the base film.

[0031] The maximum thermal shrinkage rate between 80°C and 140°C can be increased, for example, by using an ethylene copolymer, an ionomer resin, or the like as the main component of the base film. Also, the maximum thermal shrinkage rate can be increased by increasing the winding tension during the production of the base film.

[0032] The pressure-sensitive adhesive layer 2 may be a layer formed by a pressure-sensitive adhesive commonly used in dicing films. The pressure-sensitive adhesive constituting the pressure-sensitive adhesive layer 2 may be an ultraviolet-curable pressure-sensitive adhesive or a non-ultraviolet-curable pressure-sensitive adhesive. The ultraviolet-curable pressure-sensitive adhesive is a pressure-sensitive adhesive whose adhesiveness decreases upon ultraviolet irradiation. By using an ultraviolet-curable pressure-sensitive adhesive, for example, the pressure-sensitive adhesive force of the pressure-sensitive adhesive layer 2 can be reduced by ultraviolet irradiation before picking up the semiconductor chip to which the die-bonding film piece is attached.

[0033] The ultraviolet-curable pressure-sensitive adhesive may, for

example, include an acrylic resin having a (meth)acryloyl group. The acrylic resin may, for example, have a hydroxyl group. The acrylic resin is a polymer containing a (meth)acrylic acid ester as a monomer unit. The ultraviolet-curable pressure-sensitive adhesive may further contain other components such as a photopolymerization initiator and a crosslinking-agent (e.g., a polyisocyanate compound) as necessary. The crosslinking-agent is a compound having a reactive group that reacts with the acrylic resin. Examples of the crosslinking-agent include a polyisocyanate compound.

[0034] The thickness of the pressure-sensitive adhesive layer 2 may be, for example, 20 μm or less. The thickness of the pressure-sensitive adhesive layer 2 may be, for example, 18 μm or less, 16 μm or less, 14 μm or less, 12 μm or less, or 10 μm or less, and may be 1 μm or more, 2 μm or more, 3 μm or more, 4 μm or more, or 5 μm or more.

[0035] The above-mentioned tensile stress and thermal shrinkage rate of the dicing film 5 tend to depend mainly on the base film 3. Therefore, as the base film 3, one can be appropriately selected and used from among base films constituting dicing/die-bonding integrated films that are commonly used in a method for producing a semiconductor device, the method including attaching the die-bonding film of a dicing/die-bonding integrated film to a plurality of semiconductor chips under a heating condition, and singulating the die-bonding film by expanding the dicing film under cooling conditions to produce a semiconductor chip with a die-bonding film piece, such that the above-mentioned tensile stress and thermal shrinkage rate are within predetermined ranges.

[0036] The resin constituting the base film 3 includes homopolymers of

olefins such as ethylene, propylene, butene, hexene, methylpentene, 4-methyl-1-pentene, and vinyl acetate, and copolymers thereof; polyesters such as polyethylene terephthalate and polyethylene naphthalate; ethylene copolymers such as ethylene-vinyl acetate copolymer, ethylene-(meth)acrylic acid copolymer, ethylene-(meth)acrylic acid ester copolymer, and ethylene-(meth)acrylic acid-(meth)acrylic acid ester copolymer; ionomer resins having an ion-crosslinked structure formed by salt formation between an acid portion and metal ions (sodium ions, zinc ions, etc.) in a copolymer containing an olefin such as ethylene and (meth)acrylic acid; engineering plastics such as polycarbonate, polyamide, polyimide, polyether ether ketone, polyetherimide, wholly aromatic polyamide, and polyphenylene sulfide; aramid (paper); glass; glass cloth; fluororesins; chlorine-based resins such as polyvinyl chloride and polyvinylidene chloride; cellulose resins; silicone resins; or mixtures of these with a plasticizer, or cured products obtained by crosslinking through electron beam irradiation. The base film may be composed of a single type of resin, or may be composed of a mixed resin in which two or more types of resins are mixed. Further, the base film may be a film having a laminated structure in which two or more types of films are laminated. The base film may be subjected to a surface roughening treatment such as a matte treatment or a corona treatment on its surface from the viewpoint of controlling adhesion with the pressure-sensitive adhesive layer 2.

[0037] The base film 3 may be a base film including at least one resin selected from the group consisting of polyester, ethylene copolymer, ionomer resin, and engineering plastics. By using such a base film as the base film 3 of the die-bonding film 1, it tends to be easy to adjust the

above-mentioned tensile stress and the above-mentioned thermal shrinkage rate of the dicing film 5 to be within predetermined ranges. In one embodiment, the base film 3 may be a base film made of a mixed resin including an ionomer resin and a polyamide resin. The mass ratio (ionomer resin/polyamide resin) of the ionomer resin to the polyamide resin may be 50/50 to 95/5.

[0038] The base film 3 can be produced by forming a film by a conventionally known method. For example, it can be produced by adding additives such as an antistatic agent to a resin raw material for the base as necessary, melt-kneading the mixture to obtain a resin composition, and processing it into a film shape by various molding methods such as a T-die cast molding method, a T-die nip molding method, an inflation molding method, an extrusion lamination method, or a calender molding method. Further, when the base film has a laminated structure, the laminated structure can be produced by separately forming each layer into a film by means such as a calender molding method, an extrusion method, or an inflation molding method, and laminating them by means such as thermal lamination or adhesion with an adhesive. As the adhesive, an adhesive commonly used when producing a laminated structure can be used. It is also possible to produce a laminated structure by simultaneously extruding the resin compositions of each layer by a co-extrusion lamination method. Further, the surface of the base film opposite to the surface in contact with the pressure-sensitive adhesive layer may be subjected to an embossing treatment with an embossing roll for the purpose of stabilizing winding during the production of the base film 3 and preventing blocking after film formation.

[0039] The thickness of the base film 3 may be, for example, 20 to 200 μm. When the thickness of the base film 3 is 20 μm or more, sufficient process resistance can be ensured, and when the thickness of the base film 3 is 200 μm or less, it is economically advantageous. The thickness of the base film 3 may be 25 μm or more or 30 μm or more, and may be 150 μm or less or 100 μm or less.

[0040] The shape of the base film 3 may have a rectangular principal surface, but is not limited thereto. The base film 3 may be a long film, and for example, a plurality of pressure-sensitive adhesive layers 2 may be provided on a single long base film 3.

[0041] The dicing/die-bonding integrated film of the present disclosure can be suitably used in a method for producing a semiconductor device, the method including attaching the die-bonding film of the dicing/die-bonding integrated film to a plurality of semiconductor chips under a heating condition, and singulating the die-bonding film by expanding the dicing film under cooling conditions to produce a semiconductor chip with a die-bonding film piece.

[0042] [Method for Producing a Semiconductor Device]

Fig. 2 and Fig. 3 are schematic cross-sectional views showing a method for producing a semiconductor device. The method shown in Fig. 2 and Fig. 3 includes (A) attaching the die-bonding film 1 of a dicing/die-bonding integrated film 10, the integrated film including a dicing film 5 having a base film 3 and a pressure-sensitive adhesive layer 2 provided on the base film 3, and a die-bonding film 1 provided on the pressure-sensitive adhesive layer 2, to a plurality of semiconductor chips C obtained by singulating a semiconductor wafer, under a heating condition; and (B)

singulating the die-bonding film 1 by expanding the dicing film 5 under a cooling condition, thereby producing a semiconductor chip with a die-bonding film piece 30, which includes the semiconductor chip C and a die-bonding film piece 1a obtained by singulating the die-bonding film 1. The method may further include (C) picking up the semiconductor chip with a die-bonding film piece 30 from the pressure-sensitive adhesive layer 2, and (D) mounting the picked-up semiconductor chip with a die-bonding film piece 30 on a substrate or another semiconductor chip.

[0043] The semiconductor chip C is obtained by singulating a semiconductor wafer. The semiconductor wafer may be a silicon wafer, and the semiconductor chip C may be a silicon chip. The semiconductor chip C has a principal surface F1 and a principal surface F2, and for example, the principal surface F1 may be a circuit surface (front surface) and the principal surface F2 may be a back surface opposite to the circuit surface.

[0044] The thickness of the semiconductor wafer may be, for example, 50 to 3000 μm, 100 to 2000 μm, or 200 to 1500 μm.

[0045] The method for singulating the semiconductor wafer may be a stealth dicing method such as the SDBG (Stealth Dicing Before Grinding) method, or a half-cut dicing method such as the DBG (Dicing Before Grinding) method.

[0046] The stealth dicing method may be a method including, for example, attaching a protective tape (back-grind tape) to the circuit surface of a semiconductor wafer, forming a modified region inside the semiconductor wafer by laser beam irradiation, and grinding the semiconductor wafer from the back surface side and cleaving the semiconductor wafer using

the modified region as a division starting point.

[0047] The half-cut dicing method may be a method including, for example, forming a groove on the surface of a semiconductor wafer with a dicing blade, attaching a protective tape (back-grind tape) to the circuit surface of the semiconductor wafer, and grinding the semiconductor wafer from the back surface side up to the groove.

[0048] By such a method of singulating a semiconductor wafer, a laminate 20 including a protective tape 7 (back-grind tape) and a plurality of semiconductor chips C provided on the protective tape 7 can be obtained (see Fig. 2(a)). In the laminate 20, the semiconductor chips C are provided on the protective tape 7 with a kerf width kw1.

[0049] The thickness of the semiconductor chip C is smaller than the thickness of the semiconductor wafer, and may be, for example, 10 to 200 μm. The thickness of the semiconductor chip C may be 15 μm or more or 20 μm or more, and may be 150 μm or less, 100 μm or less, or 50 μm or less.

[0050] Subsequently, the die-bonding film 1 is attached to the semiconductor chip C under a heating condition, with the die-bonding film 1 of the dicing/die-bonding integrated film 10 facing the principal surface F2 of the semiconductor chip C (see Fig. 2(a)). The temperature of the heating conditions may be, for example, 60 to 80°C. Furthermore, a dicing ring DR is attached to the principal surface 2b of the pressure-sensitive adhesive layer 2 on the die-bonding film 1 side so as to surround the plurality of semiconductor chips C (see Fig. 2(b)). The protective tape 7 is peeled off from the semiconductor chip C at an appropriate timing.

[0051] In this way, a laminate 40 including the dicing/die-bonding

integrated film 10 and a plurality of semiconductor chips C provided on the die-bonding film 1 of the dicing/die-bonding integrated film 10 can be obtained. The laminate 40 may include a dicing ring DR on the principal surface 2b of the pressure-sensitive adhesive layer 2 on the die-bonding film 1 side. In the laminate 40, the semiconductor chips C are provided on the die-bonding film 1 with a kerf width kw2. The kerf width kw2 usually tends to be wider than the kerf width kw1, but if the kerf width kw2 becomes too much wider than the kerf width kw1, the separability upon cooling of the extremely thin (e.g., 20 μm or less) die-bonding film 1 tends to decrease.

[0052] Subsequently, under a cooling condition, the dicing film 5 is expanded (stretched) by pushing up the region inside the dicing ring DR of the dicing film 5 with a ring Ra (see Fig. 2(c)). The temperature of the cooling conditions may be, for example, -15 to 0°C. By expanding the dicing film 5, the die-bonding film 1 is separated. By this separation, a semiconductor chip with a die-bonding film piece 30, which has the semiconductor chip C and a die-bonding film piece 1a obtained by singulating the die-bonding film 1, is formed on the pressure-sensitive adhesive layer 2.

[0053] After the ring Ra is lowered, in the dicing film 5, the region between the dicing ring DR and the semiconductor chip with a die-bonding film piece 30 is heated by a heater H (see Fig. 3(a)). Due to the thermal shrinkage of the heated portion of the dicing film 5, the kerf width between the semiconductor chips with die-bonding film pieces 30 tends to further widen.

[0054] When the pressure-sensitive adhesive layer 2 is a layer formed by

an ultraviolet-curable pressure-sensitive adhesive, the pressure-sensitive adhesive force of the pressure-sensitive adhesive layer 2 can be reduced by ultraviolet irradiation. After reducing the pressure-sensitive adhesive force of the pressure-sensitive adhesive layer 2, each semiconductor chip with a die-bonding film piece 30 pushed up by a push-up jig 42 is picked up by a suction collet 44 (see Fig. 3(b)).

[0055] The picked-up semiconductor chip with a die-bonding film piece 30 is mounted on a substrate or another semiconductor chip. By stacking a plurality of semiconductor chips, for example, a 3D NAND flash memory can be produced.

Examples

[0056] Hereinafter, the present disclosure will be described more specifically based on examples, but the present disclosure is not limited to these examples. Unless otherwise specified, all chemicals used were reagents (commercially available products).

[0057] Example 1

1. Synthesis of acrylic resin (Production Example 1-1)

As monomers constituting the monomer units, 2-ethylhexyl acrylate (EHA), 2-hydroxyethyl acrylate (HEA), and methyl methacrylate (MMA) were provided. These monomers were mixed so that the copolymerization ratio of EHA/HEA/MMA was 78 parts by mass/21 parts by mass/1 part by mass, and an acrylic resin was obtained by solution radical polymerization using ethyl acetate as a solvent and 0.08 parts by mass of azobisisobutyronitrile (AIBN) as an initiator.

[0058] Next, using 0.05 parts by mass of hydroquinone monomethyl ether as a polymerization inhibitor, 16 parts by mass of 2-methacryloyloxyethyl

isocyanate (trade name: Karenz MOI, manufactured by Resonac Corporation, molecular weight: 155.2) was reacted with the obtained acrylic resin to obtain an ultraviolet-reactive acrylic resin having a carbon-carbon double bond (acrylic resin of Production Example 1-1). The acrylic resin of Production Example 1-1 can be an acrylic resin having a (meth)acryloyl group and a hydroxyl group. The weight-average molecular weight (in terms of standard polystyrene) of the acrylic resin of Production Example 1-1 was measured by GPC. For the GPC measurement, SD-8022/DP-8020/RI-8020 manufactured by Tosoh Corporation was used. Gelpack GL-A150-S/GL-A160-S from Resonac Corporation was used as the column. Tetrahydrofuran was used as the eluent. The weight-average molecular weight of the acrylic resin of Production Example 1-1 was 350,000. The hydroxyl value and acid value of the acrylic resin of Production Example 1-1, measured in accordance with the method described in JIS K 0070:1992, were 37.6 mgKOH/g and 6.5 mgKOH/g, respectively.

[0059] 2. Synthesis of ultraviolet-curable pressure-sensitive adhesive (Production Example 2-1)

With respect to 100 parts by mass in terms of solid content of the acrylic resin of Production Example 1-1, 2.0 parts by mass of an α-hydroxyalkylphenone-based photopolymerization initiator (trade name: Omnirad 184, manufactured by IGM Resins B.V.), 0.4 parts by mass of an acylphosphine oxide-based photopolymerization initiator (trade name: Omnirad 819, manufactured by IGM Resins B.V.), and a polyisocyanate crosslinking-agent of TDI (toluene diisocyanate) (trade name: Coronate L-45E, manufactured by Tosoh Corporation) were blended at a ratio of 4.1

parts by mass in terms of solid content, diluted with ethyl acetate, and stirred to prepare a solution of the ultraviolet-curable pressure-sensitive adhesive of Production Example 2-1.

[0060] 3. Production of base film

To an ionomer resin with a mass ratio of ethylene/methacrylic acid/2-methyl-propyl acrylate = 80/10/10 (degree of neutralization by Zn^{2+} ions: 60 mol%, melting point: 86°C, MFR (melt mass flow rate): 1 g/10 min (190°C/2.16 kg load), density: 0.96 g/cm^3), a polyamide resin (nylon 6, melting point: 225°C, density: 1.13 g/cm^3) was added so that the mass ratio of ionomer resin/polyamide resin = 90/10, and the mixture was adjusted with an extruder to have a thickness of 70 μm to obtain a base film.

[0061] 4. Production of dicing film

A solution of the ultraviolet-curable pressure-sensitive adhesive of Production Example 2-1 was applied onto a polyethylene terephthalate film (thickness: 38 μm) with one surface subjected to a release treatment so that the thickness after drying would be 10 μm, dried at 80°C for 3 minutes, to produce a pressure-sensitive adhesive layer on the polyethylene terephthalate film. Thereafter, the base film produced above, with one surface subjected to a corona discharge treatment, was attached onto the pressure-sensitive adhesive layer. The attached laminate was subjected to an aging treatment in a constant temperature bath at 23°C for 96 hours to obtain a dicing film having a base film and a pressure-sensitive adhesive layer provided on the base film.

[0062] 5. Production of die-bonding film

A mixture containing the following components and cyclohexanone was

stirred and then kneaded for 90 minutes using a bead mill.

• Epoxy resin (trade name: N500P-10, DIC Corporation, cresol novolac type epoxy resin, epoxy equivalent: 200, molecular weight: 980, softening point: 85°C): 55 parts by mass

• Phenolic resin (trade name: MEH-7800M, manufactured by Meiwa Plastic Industries, Ltd. (UBE Corporation), hydroxyl equivalent: 175): 45 parts by mass

• Silane coupling agent A (trade name: NUC A-189, manufactured by Nippon Unicar Company, Limited (ENEOS NUC Co., Ltd.), γ-mercaptopropyltrimethoxysilane): 1.7 parts by mass

• Silane coupling agent B (trade name: NUC A-1160, manufactured by Nippon Unicar Company, Limited (ENEOS NUC Co., Ltd.), γ-ureidopropyltriethoxysilane): 0.2 parts by mass

• Filler (trade name: Aerosil R972, manufactured by Nippon Aerosil Co., Ltd., silica, average particle size 0.016 μm): 32 parts by mass

Note that "Aerosil R972" is silica particles having an organic group (e.g., a methyl group) on the surface.

[0063] The following components were added to the kneaded mixture, and the mixture was further stirred. Thereafter, a varnish for forming a die-bonding film was obtained by vacuum deaeration.

• Acrylic rubber having an epoxy group (trade name: HTR-860P-3, manufactured by Nagase ChemteX Corporation, content of glycidyl acrylate or glycidyl methacrylate: 3% by mass, weight-average molecular weight: 800,000): 280 parts by mass

• Curing accelerator (trade name: Curezol 2PZ-CN, "Curezol" is a registered trademark, manufactured by Shikoku Chemicals Corporation,

1-cyanoethyl-2-phenylimidazole): 0.5 parts by mass

[0064] A polyethylene terephthalate film (thickness: 38 μm) having a release surface was provided as a carrier film. The varnish for forming a die-bonding film was applied to the release surface of the carrier film, and the coating film was heated and dried at 140°C for 5 minutes. As a result, a laminated film having the carrier film and a B-stage state die-bonding film (adhesive layer with a thickness of 10 μm) formed thereon was obtained.

[0065] 6. Production of dicing/die-bonding integrated film

The laminated film having the die-bonding film was cut into a circular shape (diameter: 312 mm). The dicing film from which the polyethylene terephthalate film had been peeled was attached to the circular die-bonding film with the pressure-sensitive adhesive layer facing the die-bonding film to obtain a laminate. The obtained laminate was left at room temperature (25°C) for one day. Thereafter, in the dicing film, the outside of the portion attached to the die-bonding film was cut to obtain a dicing/die-bonding integrated film of Example 1, including a circular die-bonding film and a circular (diameter: 370 mm) dicing film that covers the die-bonding film and has a portion protruding from the die-bonding film. By the same operation, a plurality of dicing/die-bonding integrated films of Example 1 were produced to be subjected to various evaluation tests described later.

[0066] Example 2

A plurality of dicing/die-bonding integrated films of Example 2 were produced in the same manner as in Example 1, except that the thickness of the base film was changed from 70 μm to 80 μm.

[0067] Example 3

A plurality of dicing/die-bonding integrated films of Example 3 were produced in the same manner as in Example 1, except that the following base film was used.

[0068] To an ionomer resin with a mass ratio of ethylene/methacrylic acid/2-methyl-propyl acrylate = 80/10/10 (degree of neutralization by Zn^{2+} ions: 60 mol%, melting point: 86°C, MFR (melt mass flow rate): 1 g/10 min (190°C/2.16 kg load), density: 0.96 g/cm^3), a polyamide resin (nylon 6, melting point: 225°C, density: 1.13 g/cm^3) was added so that the mass ratio of ionomer resin/polyamide resin = 90/10 to obtain a mixed resin A. Subsequently, an antistatic agent of 30 parts by mass or less was added to the mixed resin A, where the total amount of the mixed resin A was 100 parts by mass, to obtain a mixed resin B. A base film was obtained by adjusting with an extruder so that the thickness ratio of the layer made of mixed resin A/the layer made of mixed resin B = 65/15, and the total thickness of the layer made of mixed resin A and the layer made of mixed resin B was 80 μm. The pressure-sensitive adhesive layer was formed on the layer made of mixed resin A of the base film.

[0069] Example 4

A plurality of dicing/die-bonding integrated films of Example 4 were produced in the same manner as in Example 1, except for the following changes.

(1) The acrylic resin of Production Example 1-1 was changed to the acrylic resin of Production Example 1-2 with the composition shown in Table 1. The acrylic resin of Production Example 1-2 was synthesized in the same manner as the acrylic resin of Production Example 1-1, except that the

composition was changed to that shown in Table 1.

(2) The ultraviolet-curable pressure-sensitive adhesive of Production Example 2-1 was changed to the ultraviolet-curable pressure-sensitive adhesive of Production Example 2-2 with the composition shown in Table 2. The ultraviolet-curable pressure-sensitive adhesive of Production Example 2-2 was synthesized in the same manner as the ultraviolet-curable pressure-sensitive adhesive of Production Example 2-1, except that the composition was changed to that shown in Table 2.

(3) The thickness of the pressure-sensitive adhesive layer was changed from 10 μm to 8 μm.

(4) The base film with a mass ratio of ionomer resin/polyamide resin = 90/10 was changed to a base film with a mass ratio of ionomer resin/polyamide resin = 80/20.

[0070] Example 5

A plurality of dicing/die-bonding integrated films of Example 5 were produced in the same manner as in Example 4, except that the thickness of the base film was changed from 70 μm to 80 μm.

[0071] Example 6

A plurality of dicing/die-bonding integrated films of Example 6 were produced in the same manner as in Example 4, except that the thickness of the base film was changed from 70 μm to 90 μm.

[0072] Comparative Example 1

A plurality of dicing/die-bonding integrated films of Comparative Example 1 were produced in the same manner as in Example 1, except that the thickness of the base film was changed from 70 μm to 90 μm.

[0073] Comparative Example 2

A plurality of dicing/die-bonding integrated films of Comparative Example 2 were produced in the same manner as in Comparative Example 1, except that the base film with a mass ratio of ionomer resin/polyamide resin = 90/10 was changed to a base film made of ionomer resin, i.e., with a mass ratio of ionomer resin/polyamide resin = 100/0.

[0074] Comparative Example 3

A plurality of dicing/die-bonding integrated films of Comparative Example 3 were produced in the same manner as in Comparative Example 2, except for the following changes.

(1) The acrylic resin of Production Example 1-1 was changed to the acrylic resin of Production Example 1-2 with the composition shown in Table 1.

(2) The ultraviolet-curable pressure-sensitive adhesive of Production Example 2-1 was changed to the ultraviolet-curable pressure-sensitive adhesive of Production Example 2-2 with the composition shown in Table 2.

(3) The thickness of the pressure-sensitive adhesive layer was changed from 10 μm to 8 μm.

[0075] Comparative Example 4

A plurality of dicing/die-bonding integrated films of Comparative Example 4 were produced in the same manner as in Example 1, except for the following changes.

(1) The acrylic resin of Production Example 1-1 was changed to the acrylic resin of Production Example 1-3 with the composition shown in Table 1. The acrylic resin of Production Example 1-3 was synthesized in the same manner as the acrylic resin of Production Example 1-1, except that the composition was changed to that shown in Table 1.

(2) The ultraviolet-curable pressure-sensitive adhesive of Production Example 2-1 was changed to the ultraviolet-curable pressure-sensitive adhesive of Production Example 2-3 with the composition shown in Table 2. The ultraviolet-curable pressure-sensitive adhesive of Production Example 2-3 was synthesized in the same manner as the ultraviolet-curable pressure-sensitive adhesive of Production Example 2-1, except that the composition was changed to that shown in Table 2.

(3) The base film with a mass ratio of ionomer resin/polyamide resin = 90/10 and a thickness of 70 μm was changed to a multilayer base film obtained by adjusting with an extruder so that the thickness ratio was ethylene-methacrylic acid copolymer/vinyl acetate polymer/ethylene-methacrylic acid copolymer = 1/8/1, and the thickness was 80 μm.

[0076] Comparative Example 5

A plurality of dicing/die-bonding integrated films of Comparative Example 5 were produced in the same manner as in Comparative Example 4, except that the base film with a thickness ratio of ethylene-methacrylic acid copolymer/vinyl acetate polymer/ethylene-methacrylic acid copolymer = 1/8/1 was changed to a multilayer base film obtained by adjusting with an extruder so that the thickness ratio was polypropylene/vinyl acetate polymer/polypropylene = 1/8/1, and the thickness was 100 μm.

[0077] [Table 1]

Acrylic Resin			Prod. Exam. 1-1	Prod. Exam. 1-2	Prod. Exam. 1-3
Composition (parts by mass)	Monomer	EHA	78.0	78.5	79.0
		HEA	21.0	21.0	20.0
		MMA	1.0	0.5	1.0
		(Total)	100	100	100
	Karenz MOI		16.0	21.0	13.8
Weight-average molecular weight (Mw)			3.5×10^5	3.5×10^5	8.0×10^5
Hydroxyl value (mgKOH/g)			37.6	23.1	33.5
Acid value (mgKOH/g)			6.5	3.3	6.5

[0078] [Table 2]

Ultraviolet-curable Pressure-sensitive Adhesive			Prod. Exam. 2-1	Prod. Exam. 2-2	Prod. Exam. 2-3
Composition (parts by mass)	Acrylic Resin	Prod. Exam. 1-1	100	-	-
		Prod. Exam. 1-2	-	100	-
		Prod. Exam. 1-3	-	-	100
	Photo-polymerization initiator	Omnirad 184	2.0	2.0	3.0
		Omnirad 819	0.4	0.4	0.6
	Crosslinking agent	L-45E	4.1	1.2	4.1

[0079] Evaluation

(1) Evaluation of Dicing Film Properties

(1-1) Measurement of tensile stress at 20% elongation at 0°C in tensile test

For each dicing film of the dicing/die-bonding integrated films of Examples 1 to 6 and Comparative Examples 1 to 5, a tensile test was performed in accordance with JIS K 7161-1:2014 using a Tensilon (RTF-1250-HS-PL, manufactured by A&D Company, Limited) with the

following sample under the measurement conditions to obtain an S-S curve (stress-strain curve). In the obtained S-S curve, the stress value in the MD direction (flow direction) of the base film at 20% elongation was read, and this was taken as the value of the tensile stress. The results are shown in Table 3 and Table 4.

(Measurement Conditions)

Sample: Dumbbell-shaped No. 1 test piece

Chuck distance: 40 mm

Temperature condition: 0°C ± 2°C

Tensile speed: 300 mm/min

[0080] (1-2) Measurement of thermal shrinkage rate at 70°C and maximum thermal shrinkage rate between 80°C and 140°C in thermomechanical analysis

For each dicing film of the dicing/die-bonding integrated films of Examples 1 to 6 and Comparative Examples 1 to 5, a test specimen having a size of 25 mm in length and 4 mm in width was cut out. The cutting direction was such that the MD direction (flow direction) of the dicing film was 25 mm in length, and the TD direction (perpendicular direction) was 4 mm in width. Next, using a thermomechanical analyzer (TMA7100, manufactured by Hitachi High-Tech Corporation), the thermal shrinkage amount of the dicing film in the MD direction was measured for the test specimen under the following measurement conditions. The value of the thermal shrinkage amount at 70°C and the maximum value of the thermal shrinkage amount between 80°C and 140°C were read, respectively, and by dividing by the initial length of the test specimen measured with the thermomechanical analyzer, the respective thermal shrinkage rates were

obtained. The results are shown in Table 3 and Table 4.

(Measurement Conditions)

Chuck distance: 10 mm (width 4 mm)

Load: 0 mN

Temperature range: 30 to 180°C

Heating rate: 5°C/min

[0081] (2) Evaluation of Processability

(2-1) Production of Sample for Processability Evaluation

A sample for processability evaluation was produced according to the following procedure. A protective tape was attached to the surface of a silicon wafer (diameter: 12 inches, thickness: 775 μm). Thereafter, the silicon wafer was singulated by stealth dicing. That is, a modified region was formed inside the silicon wafer by irradiating the surface (back surface) of the silicon wafer opposite to the side to which the protective tape was attached with a laser beam under the following conditions.

(Stealth Dicing Conditions)

• Stealth dicing apparatus: DFL7361 (manufactured by DISCO Corporation)

• Laser oscillator type: Semiconductor laser-pumped Q-switched solid-state laser

• Wavelength: 1342 nm

• Frequency: 60 kHz

• Output: 0.8 W

• Number of passes: 2

• Chip size: 3 mm x 12 mm

• Dicing speed: 800 mm/sec

[0082] Subsequently, the surface of the silicon wafer opposite to the protective tape was ground (polished) using a grinder-polisher apparatus (DGP8761, manufactured by DISCO Corporation) until the thickness of the silicon wafer became 30 μm, and the silicon wafer was singulated to obtain silicon chips. The die-bonding film of the dicing/die-bonding integrated film of Examples 1 to 6 and Comparative Examples 1 to 5 was attached to the surface of the silicon chip opposite to the protective tape under the following attachment conditions. At this time, the orientation of the attachment was adjusted so that the direction of the division lines of the silicon chip was along the MD direction and TD direction of the base film of the dicing/die-bonding integrated film. Furthermore, the adhesive layer in the portion protruding from the die-bonding film was attached to a dicing ring, and then the protective tape was peeled off from the silicon wafer.

(Attachment Conditions)

- Attachment apparatus: DFM2800 (manufactured by DISCO Corporation)
- Attachment temperature: 65°C
- Attachment speed: 10 mm/s
- Attachment tension level: Level 7

[0083] Next, using a die separator (DDS2300, manufactured by DISCO Corporation), the dicing film of the dicing/die-bonding integrated film was stretched by cooling expansion under the following cooling expansion conditions, thereby dividing the die-bonding film. Thereafter, the dicing film was shrunk by heating (thermal shrinkage) under the following heating conditions.

(Cooling expansion Conditions)

• Cooling temperature: 0°C

• Cooling time: 120 seconds

• Push-up amount: 8 mm

• Push-up speed: 120 mm/sec

• Holding time after push-up: 10 seconds

(Heating Conditions)

• Heater temperature: 250°C

• Heater rotation speed: 10°/sec

• Push-up amount: 8 mm

• Tape cooling waiting time: 10 seconds

[0084] After the shrinkage of the dicing film, the pressure-sensitive adhesive layer was irradiated with ultraviolet rays under the following conditions, thereby reducing the pressure-sensitive adhesive force of the pressure-sensitive adhesive layer.

(Ultraviolet Irradiation Conditions)

• Ultraviolet intensity: 100 mW/cm^2

• Ultraviolet exposure: 150 mJ/cm^2

[0085] (2-2) Evaluation

(a) Measurement of kerf width after attachment

In "(2-1) Production of Sample for Processability Evaluation," for the sample after attaching the dicing/die-bonding integrated film to the silicon chips, the kerf width (width of the grid-like gap) formed between adjacent chips was measured by microscopic observation. Fig. 5 is a top view showing measurement points in the measurement of kerf width after attachment in the examples, where Fig. 5(a) is a top view showing

measurement points at an end portion of the semiconductor wafer, and Fig. 5(b) is a top view showing measurement points at a central portion of the semiconductor wafer. For the kerf width at the end portion of the semiconductor wafer, the kerf width in the MD direction was measured at 12 points indicated by black circles in Fig. 5(a), and the average value was obtained from the 12 data points. For the kerf width at the central portion of the semiconductor wafer, the kerf width in the MD direction was measured at 5 points indicated by black circles in Fig. 5(b), and the average value was obtained from the 5 data points. The results are shown in Table 3 and Table 4.

[0086] (b) Evaluation of separability

In "(2-1) Production of Sample for Processability Evaluation," for the sample after dividing the die-bonding film by cooling expansion, the separability was evaluated based on the following criteria according to the number of unseparated portions of the die-bonding film. In the evaluation of separability, the end portion of the semiconductor wafer was defined as the region from both ends in the MD direction of the semiconductor wafer to the fifth dicing line, and the central portion of the semiconductor wafer was defined as the region other than the end portion of the semiconductor wafer (see Fig. 4), and the number of unseparated portions of the die-bonding film in each region was determined. The results are shown in Table 3 and Table 4.

A: 0

B: 1 or more and less than 5

C: 5 or more and less than 10

D: 10 or more

[0087] (c) Measurement of kerf width after thermal shrinkage

In "(2-1) Production of Sample for Processability Evaluation," for the sample after shrinking the dicing film by heating, the kerf width (width of the grid-like gap) formed between adjacent chips was measured by microscopic observation. Fig. 6 is a top view showing measurement points in the measurement of kerf width after thermal shrinkage in the examples. For the kerf width of the semiconductor wafer, the kerf width in the MD direction and the kerf width in the TD direction were measured at 9 points indicated by black circles in Fig. 6, respectively, an average value was obtained from the 18 data points, and that the kerf width was well secured was evaluated based on the following criteria. The results are shown in Table 3 and Table 4.

A: 30 μm or more

B: 20 μm or more and less than 30 μm

C: Less than 20 μm

[0088] [Table 3]

Item		Exam.1	Exam.2	Exam.3	Exam.4	Exam.5	Exam.6
Tensile stress (0°C) (MPa)		20.0	19.6	17.1	19.9	19.7	24.6
Thermal shrinkage rate (70°C) (%)		2.4	2.7	3.4	2.8	3.4	3.9
Maximum thermal shrinkage rate (80-140°C) (%)		13.7	13.4	26.9	23.5	20.6	19.2
Kerf width after attachment (μm)	Edge	5.6	5.5	5.5	5.3	5.3	5.5
	Center	3.4	3.5	4.3	1.9	2.4	2.3
Separability	Edge	A	A	A	A	A	A
	Center	A	A	A	A	A	A
Kerf width after heat shrinkage		A	A	A	A	A	A

[0089] [Table 4]

Item		Comp. Exam.1	Comp. Exam.2	Comp. Exam.3	Comp. Exam.4	Comp. Exam.5
Tensile stress (0°C) (MPa)		20.2	17.3	18.3	7.3	11.5
Thermal shrinkage rate (70°C) (%)		5.3	7.2	8.7	3.8	3.0
Maximum thermal shrinkage rate (80-140°C) (%)		40.9	41.4	42.1	15.1	2.8
Kerf width after attachment (μm)	Edge	7.4	8.2	9.6	3.2	4.3
	Center	4.7	4.4	6.3	0.9	3.2
Separability	Edge	B	B	C	A	A
	Center	A	A	A	D	C
Kerf width after heat shrinkage		A	A	A	B	C

[0090] As shown in Table 3 and Table 4, for the dicing/die-bonding integrated films of Comparative Examples 1 to 3, in which the thermal shrinkage rate of the dicing film at 70°C exceeded 5%, the separability of the die-bonding film at the silicon wafer end portion was insufficient. Also, for the dicing/die-bonding integrated films of Comparative Examples 4 and 5, in which the tensile stress of the dicing film at 0°C was less than 15 MPa, the separability of the die-bonding film at the silicon wafer central portion was insufficient. In contrast, it was found that for the dicing/die-bonding integrated films of Examples 1 to 6, in which the thermal shrinkage rate of the dicing film at 70°C was 5% or less and the tensile stress of the dicing film at 0°C was 15 MPa or more, the separability of the die-bonding film was improved. Furthermore, it was also found that when the maximum thermal shrinkage rate of the dicing film of the dicing/die-bonding integrated film between 80°C and 140°C was 10% or more, the kerf width after thermal shrinkage of the dicing film was well secured.

[0091] From the above, it was confirmed that according to the present disclosure, it is possible to improve the separability upon cooling of a die-bonding film having a thickness of 20 μm or less in a predetermined method for producing a semiconductor device.

Reference Signs List

[0092] 1... die-bonding film, 1a... die-bonding film piece, 2... pressure-sensitive adhesive layer, 3... base film, 5... dicing film, 7... protective tape, 10... dicing/die-bonding integrated film, 30... semiconductor chip with a die-bonding film piece, C... semiconductor chip.