

DESCRIPTION

Title of Invention

METHOD OF MANUFACTURING SEMICONDUCTOR DEVICE AND
SEMICONDUCTOR WAFER SURFACE PROTECTION FILM USED
5 THEREIN

Technical Field

[0001] The present invention relates to a method of manufacturing a
semiconductor device and a semiconductor wafer surface protection
10 film used therein.

Background Art

[0002] Thinning of a semiconductor wafer during the semiconductor
device manufacturing process is typically accomplished by grinding a
15 non-patterned surface (rear surface) of the semiconductor wafer. The
patterned surface of the semiconductor wafer is protected using various
methods during the rear surface grinding.

[0003] For example, the patterned surface of a semiconductor wafer
formed of a sapphire substrate is protected by the method described
20 below (see, e.g., PTL 1 and NPL 1). Specifically, a ceramic plate
having a wax resin layer on its surface is prepared. The wax resin
layer is then heated and molten allowing the patterned surface of the
sapphire substrate to be buried in the molten wax resin layer.
Subsequently, the wax resin layer is cooled and solidified. As a result,
25 the entire patterned surface of the sapphire substrate is protected by the
wax resin layer. The wax resin typically includes a rosin wax (i.e., a

wax containing for example rosin, montan wax, and phenol resin) having a melting point of about 50°C.

Citation List

5 Patent Literature

[0004]

[PTL 1] WO2005/099057

Non-Patent Literature

[0005]

- 10 [NPL 1] Internet News Release on Press of DISCO Corporation, dated November 5, 2009 (URL: <http://www.disco.co.jp/jp/news/press/20091105.html>)

Summary of Invention

15 Technical Problem

- [0006] However, in the method described above, it is necessary to heat and melt the wax resin layer in order to separate the sapphire substrate, which has been subjected to rear surface grinding, from the wax resin layer. In addition, it is necessary to wash out the wax resin
- 20 remaining on the surface of the sapphire wafer using a solvent, which makes the process cumbersome. Furthermore, since the sapphire substrate subjected to rear surface grinding has a very small thickness and therefore is easily bent, a fracture may easily occur during such a process.
- 25 [0007] To solve the foregoing problems, the inventors contrived to provide a method of protecting the patterned surface of a sapphire

substrate using a semiconductor wafer protection film that can be relatively easily separated from the substrate. The conventional semiconductor wafer protection film includes a base layer and an adhesive layer. In addition, the adhesive layer of the semiconductor
5 wafer protection film is attached to the patterned surface of the semiconductor wafer, followed by rear surface grinding on the semiconductor wafer. The semiconductor wafer protection film is then separated using for example a tape stripper.

[0008] However, methods that use the conventional semiconductor
10 wafer protection films have suffered from a problem that the edge portion of the sapphire substrate is prone to damages during rear surface grinding. That is, as illustrated in Fig. 3, in the wax-based method, the entire edge portion of sapphire wafer 1 is buried in wax resin layer 2, and therefore, the edge portion of sapphire substrate 1
15 tends to be stably held. On the other hand, as illustrated in Fig. 4, in a method that uses the conventional semiconductor wafer protection film, the edge portion of sapphire substrate 1 is not buried in the inside of semiconductor wafer protection film 4. Therefore, it is difficult to stably hold the edge portion of sapphire substrate 1. For this reason,
20 it is conceived that the edge portion of sapphire substrate 1 is easily damaged when it makes contact with abrasive material 3 and the like during rear surface grinding.

[0009] The present invention has been made in view of the foregoing problems pertinent in the art and provides a method of manufacturing a
25 semiconductor device that allows rear surface grinding without causing damages even to a hard, fragile semiconductor wafer such as a sapphire

substrate, and a semiconductor wafer surface protection film suitable for the aforementioned manufacturing method.

Solution to Problem

5 [0010] The inventors established that damages to the edge portion of the semiconductor wafer can be limited by holding the edge or other nearby portion of the semiconductor wafer by means of a raised portion (rim) during rear surface grinding. In addition, the inventors made diligent efforts to find a film configuration capable of relatively easily
10 forming the raised portion (rim) through thermocompression bonding and appropriately retaining the shape of the raised portion (rim) even at a temperature of the rear surface grinding.

[0011] A first aspect of the present invention relates to the following semiconductor wafer surface protection film.

15 [1] A semiconductor wafer surface protection film including:
base layer (A) having a storage elastic modulus at 150°C ($G_A(150)$) of equal to or higher than 1 MPa; and
softening layer (B) having a storage elastic modulus at a temperature selected from 120 to 180° ($G_B(120 \text{ to } 180)$) of equal to or
20 lower than 0.05 MPa and a storage elastic modulus at 40°C ($G_B(40)$) of equal to or higher than 10 MPa .

[2] The semiconductor wafer surface protection film according to [1], wherein a storage elastic modulus at 100°C ($G_B(100)$) of the softening layer (B) is equal to or higher than 1 MPa.

25 [3] The semiconductor wafer surface protection film according to [1] or [2], wherein a tensile elastic modulus at 60°C $E_B(60)$ of the

softening layer (B) and a tensile elastic modulus at 25°C ($E_B(25)$) of the softening layer (B) satisfy the relationship $1 > E_B(60)/E_B(25) > 0.1$.

[4] The semiconductor wafer surface protection film according to any one of [1] to [3], further including adhesive layer (C) disposed
5 opposite to the base layer (A) across the softening layer (B),

wherein an adhesive force of the adhesive layer (C) measured in accordance with JIS-Z0237 is 0.1 to 10 N/25 mm.

[5] The semiconductor wafer surface protection film according to [1] to [4], wherein the base layer (A) is an outermost layer of the
10 semiconductor wafer surface protection film.

[6] The semiconductor wafer surface protection film according to [4] or [5], wherein the adhesive layer (C) is an outermost layer positioned opposite to the base layer (A) across the softening layer (B).

[7] The semiconductor wafer surface protection film according to any one of [1] to [6], wherein the softening layer (B) includes a
15 homopolymer of a hydrocarbon olefin, a copolymer of a hydrocarbon olefin, or a mixture thereof.

[8] The semiconductor wafer surface protection film according to any one of [1] to [7], wherein a resin constituting the softening layer
20 (B) has a density of 880 to 960 kg/m³.

[9] The semiconductor wafer surface protection film according to any one of [1] to [8], wherein the base layer (A) is a polyolefin layer, a polyester layer, or a laminate of the polyolefin layer and the polyester layer.

25 [0012] A second aspect of the present invention relates to the following method of manufacturing a semiconductor device. [10] A

method of manufacturing a semiconductor device, including:

disposing a semiconductor wafer on a semiconductor wafer surface protection film such that a patterned surface of the semiconductor wafer contacts the semiconductor wafer surface protection film;

forming around a circumference of the semiconductor wafer a raised portion of the semiconductor wafer surface protection film for holding the semiconductor wafer;

grinding a non-patterned surface of the semiconductor wafer held by the raised portion; and

separating the semiconductor wafer surface protection film from the patterned surface of the semiconductor wafer,

wherein a storage elastic modulus at 100°C (G(100)) of the raised portion is equal to or higher than 1 MPa.

[11] The method according to [10], wherein the semiconductor wafer surface protection film is the semiconductor wafer surface protection film according to any one of [1] to [9], and

the raised portion is formed by performing thermocompression bonding for the semiconductor wafer surface protection film and the semiconductor wafer under a pressure of 1 to 10 MPa at 120 to 180°C.

[12] The method according to [11], wherein temperature T_M of the film in the step of disposing the semiconductor wafer on the semiconductor wafer surface protection film such that the patterned surface of the semiconductor wafer contacts the semiconductor wafer surface protection film, a thermocompression bonding temperature T_P in the step of forming the raised portion of the semiconductor wafer

surface protection film, and softening temperature T_{mB} of the softening layer (B) satisfy relationships represented by the following equations:

[1]

$$5 \quad TP \leq TM \quad \dots(\text{Equation 1})$$

[2]

$$T_{mB} < TP < T_{mB} + 40^{\circ}\text{C} \quad \dots(\text{Equation 2})$$

[13] The method according to [11] or [12], wherein the semiconductor wafer is disposed on the semiconductor wafer surface protection film such that the softening layer (B) of the semiconductor wafer surface protection film is disposed on the patterned surface side of the semiconductor wafer relative to the base layer (A).

[14] The method according to any one of [10] to [13], wherein the semiconductor wafer includes a high-hardness substrate having a Mohs' hardness of 8 or higher.

[0013] A third aspect of the present invention relates to the following semiconductor wafer press apparatus.

[15] A semiconductor wafer press apparatus that presses a mount frame that includes a semiconductor wafer, ring frame A having a rim surrounding the semiconductor wafer, and the semiconductor wafer surface protection film according to claim 1 attached over a patterned surface of the semiconductor wafer and the frame A, with the mount frame being interposed between an upper press plate having a heating mechanism and a lower press plate opposite to the upper press plate,

wherein outer diameter DW of the semiconductor wafer and inner diameter DA_{IN} of ring frame A satisfy the relationship Equation

(1): $DW < DA_{IN}$,

the lower press plate has a protrusion on a surface opposite to the upper press plate, and

a circumference of a surface of the protrusion that makes
5 contact with the mount frame at the time of pressing has a circular shape.

[16] The semiconductor wafer press apparatus according to [15], wherein the protrusion has a height of 1 to 100 μm .

[17] The semiconductor wafer press apparatus according to [15]
10 or [16], wherein a height of the protrusion is within 15 to 100% of a thickness of the softening layer (B) of the semiconductor wafer surface protection film.

[18] The semiconductor wafer press apparatus according to any one of [15] to [17], wherein diameter CD of the protrusion satisfies the
15 relationship $DW < CD < DA_{IN}$.

[0014] A fourth aspect of the present invention relates to the following semiconductor wafer mount apparatus for manufacturing a mount frame and method of manufacturing a semiconductor device using the same.

20 [19] A semiconductor wafer mount apparatus for manufacturing a mount frame including a semiconductor wafer, ring-like supporting member B surrounding the semiconductor wafer, ring frame A surrounding the semiconductor wafer and ring-like supporting member B, and the semiconductor wafer surface protection film according to
25 any one of [1] to [9] attached across a patterned surface of the semiconductor wafer, ring-like supporting member B, and ring frame A,

wherein

wherein outer diameter DW of the semiconductor wafer, an inner diameter DA_{IN} of ring frame A, ring outer diameter DB_{OUT} of ring-like supporting member B, and ring inner diameter DB_{IN} of ring-like supporting member B satisfy the relationship Equation (1): $DW < DB_{IN} < DB_{OUT} < DA_{IN}$, and

the semiconductor wafer mount apparatus comprises:

a heating unit that heats a surface opposite to a patterned surface of the semiconductor wafer;

an attaching roller that rolls over a patterned surface of the semiconductor wafer, ring frame A, and ring-like supporting member B to attach the semiconductor wafer surface protection film; and

a tape cutting mechanism that cuts the surface protection film along an exterior shape of ring frame A.

[20] The semiconductor wafer mount apparatus according to [19], wherein both differences $\Delta D1$ and $\Delta D2$ expressed as the following equations are within 1% of outer diameter DW of the semiconductor wafer:

$$\Delta D1 = DB_{IN} - DW; \dots (2)$$

$$\Delta D2 = DA_{IN} - DB_{OUT} \dots (3)$$

[0015] A fifth aspect of the present invention relates to the following method of manufacturing a semiconductor device.

A method of manufacturing a semiconductor device including:

1') providing a semiconductor wafer,

2') forming a raised portion substantially made of resin around a circumference of the semiconductor wafer,

3') disposing a patterned surface of the semiconductor wafer on a semiconductor wafer surface protection film,

4') grinding a non-patterned surface of the semiconductor wafer held by the raised portion, and

5 5') separating the semiconductor wafer surface protection film, wherein

the raised portion made of resin has storage elastic modulus $G_B(40)$ of equal to or higher than 10 MPa.

10 Advantageous Effects of Invention

[0016] The semiconductor wafer surface protection film according to the present invention allows for rear surface grinding without causing damages even to hard, fragile semiconductor wafers such as sapphire wafers.

15

Brief Description of Drawings

[0017]

Fig. 1A is a schematic diagram illustrating a semiconductor wafer surface protection film according to an embodiment of the present invention;

Fig. 1B is a schematic diagram illustrating a semiconductor wafer surface protection film according to another embodiment of the present invention;

Fig. 2A is a diagram illustrating an exemplary process of disposing a semiconductor wafer on a semiconductor wafer surface protection film (mount process);

Fig. 2B is a diagram illustrating a laminate obtained by disposing a semiconductor wafer on a semiconductor wafer surface protection film;

Fig. 2C is a diagram illustrating an exemplary process of forming a raised portion of the semiconductor surface protection film around a circumference of the semiconductor wafer (press process);

Fig. 2D is an enlarged view illustrating an exemplary raised portion;

Fig. 2E is a diagram illustrating an exemplary process of grinding a non-patterned surface of the semiconductor wafer;

Fig. 3 is a diagram illustrating an exemplary method of protecting a semiconductor wafer according to a conventional wax-based method;

Fig. 4 is a diagram illustrating an exemplary method of protecting a semiconductor wafer using a conventional semiconductor wafer surface protection film;

Figs. 5A and 5B are diagrams illustrating a mount process according to another embodiment;

Fig. 6 is a diagram illustrating a state that a thickness of the semiconductor wafer surface protection film becomes uneven through the press process;

Fig. 7A is a diagram illustrating a press process according to another embodiment;

Figs. 7B to 7C are diagrams illustrating exemplary shapes of the protrusion; and

Fig. 8 is a diagram illustrating a method of forming a raised

portion separate from the semiconductor surface protection film around a circumference of the semiconductor wafer.

Description of Embodiments

5 [0018] 1. Semiconductor Wafer Surface Protection Film

A semiconductor wafer surface protection film according to the present invention includes base layer (A) and softening layer (B). The semiconductor wafer surface protection film according to the present invention may further include adhesive layer (C) (see Fig. 1A) or less
10 adhesive layer (D) (see Fig. 1B) as necessary. A thickness of the film according to the present invention is not particularly limited, and the film may be called a sheet.

[0019] Base Layer (A)

Base layer (A) has a function of limiting bending of a
15 semiconductor wafer for retaining the wafer's shape when thermocompression bonding is performed between the semiconductor wafer surface protection film and the semiconductor wafer. For this reason, base layer (A) preferably has a storage elastic modulus equal to or higher than a predetermined level at a thermocompression bonding
20 temperature (about 120 to 180°C). Specifically, storage elastic modulus at 150°C ($G_A(150)$) of base layer (A) is preferably set to 1 MPa or higher, and more preferably, 2 MPa or higher.

[0020] The storage elastic modulus of base layer (A) may be measured through the following method. That is, a sample film made of the
25 same resin as that of base layer (A) with a thickness of 500 μm is prepared. Then, the sample film is set on a dynamic viscoelasticity

test station (ARES series rheometer, produced by TA INSTRUMENTS, Inc.), and a storage elastic modulus is measured by increasing a temperature up to 200°C at a rate of 3°C/min. from 30°C using a parallel plate type attachment having a diameter of 8 mm. A measurement frequency may be set to 1 Hz. After terminating the measurement, storage elastic modulus G(Pa) at 150°C is read from the obtained storage elastic modulus/temperature curve within a temperature range of 30 to 200°C.

[0021] Base layer (A) may be made of resin satisfying the storage elastic modulus described above. In addition, as described below, in a case where adhesive layer (C) is made of a radiation curable adhesive, base layer (A) is preferably made of transparent resin. Such resin may include a polyolefin and a polyester. That is, base layer (A) may be, for example, a polyolefin film, a polyester film, or a laminated film including a polyolefin layer and a polyester layer. The polyolefin film may be, for example, a polypropylene film. The polyester film may be, for example, a polyethylene-terephthalate film, a polyethylene naphthalate film, or the like.

[0022] The resin constituting base layer (A) preferably has a density of 900 to 1450 kg/m³. If the resin constituting base layer (A) has a density lower than 900 kg/m³, the storage elastic modulus is too low, so that shape retention is not sufficient.

[0023] Base layer (A) preferably has a thickness of 5 μm or greater, and more preferably, 10 μm or greater in order to obtain rigidity sufficient to limit bending of the semiconductor wafer. An upper limit of the thickness of base layer (A) may be set such that a total thickness

of the semiconductor wafer surface protection film is not excessively thick compared to a grinding finish thickness of the semiconductor wafer in order to prevent damage to the semiconductor wafer.

[0024] Softening Layer (B)

5 Softening layer (B) has a function of forming a raised portion (rim) around the semiconductor wafer in order to stably hold an edge portion of the semiconductor wafer. As will be described later, because there are cases where the raised portion (rim) is formed by performing thermocompression bonding between the semiconductor
10 wafer surface protection film and the semiconductor wafer, it is necessary to soften softening layer (B) at a thermocompression bonding temperature (120 to 180°C). That is, softening temperature T_{mB} of softening layer (B) is preferably lower than the thermocompression bonding temperature (120 to 180°C). Softening temperature T_{mB} can
15 be obtained through DSC measurement. Specifically, a melting point (in the DSC method) of a resin material according to the standard ISO-11357-3 is set to the softening temperature.

[0025] A storage elastic modulus of softening layer (B) at a temperature selected from 120 to 180°C ($G_B(120 \text{ to } 180)$), preferably a
20 storage elastic modulus of softening layer (B) at 150°C ($G_B(150)$), is preferably set to 0.05 MPa or lower, and more preferably, 0.03 MPa or lower.

[0026] In order to prevent the raised portion (rim) from being softened during rear surface grinding (wet polishing), it is necessary to
25 prevent softening layer (B) from being softened at a temperature upon rear surface grinding (about 40°C). For this reason, a storage elastic

modulus at 40°C ($G_B(40)$) is preferably set to 10 MPa or higher, more preferably 20 MPa or higher, and further preferably, 30 MPa or higher. Typically, the upper limit of the storage elastic modulus at 40°C ($G_B(40)$) may be set to about 500 MPa or lower. In order to set storage
5 elastic modulus at 40°C ($G_B(40)$) of softening layer (B) to 10 MPa or higher, it is preferable that softening layer (B) be made of resin other than elastomer as described below. As described below, storage elastic modulus G is one-third the tensile elastic modulus E . For example, the phrase “storage elastic modulus at temperature 40°C
10 ($G_B(40)$) of softening layer (B) is set to 10 MPa or higher” may be rephrased as “tensile elastic modulus at 40°C ($E_B(40)$) of softening layer (B) is set to 30 MPa or higher.”

[0027] The rear surface grinding is typically performed in wet process, but it may be also performed in dry process as necessary. In
15 some cases, the wafer temperature during a dry rear surface grinding process (dry polishing) reach as high as 100°C due to a significant frictional heat between the abrasive material and the semiconductor wafer. For this reason, in order to prevent the raised portion (rim) from being softened even during dry polishing, a storage elastic
20 modulus at 100°C ($G_B(100)$) of softening layer (B) is preferably set to 1 MPa or higher, and more preferably, 3 MPa or higher.

[0028] A relationship between tensile elastic modulus at 60°C ($E_B(60)$) and tensile elastic modulus at 25°C $E_B(25)$ of softening layer (B) preferably satisfies the relationship $1 > E_B(60)/E_B(25) > 0.1$. The
25 temperature of the semiconductor wafer during rear surface grinding of the semiconductor wafer usually changes between 25°C and 60°C.

Thus, when the change rate of the storage elastic modulus of softening layer (B) within this temperature range is within a certain range, the raised portion formed of softening layer (B) can stably hold the semiconductor wafer. In addition, it is possible to limit the raised portion formed of softening layer (B) from being deteriorated during the rear surface grinding of the semiconductor wafer. For this reason, it is possible to more effectively limit damage to the semiconductor wafer during the rear surface grinding of the semiconductor wafer.

[0029] Tensile elastic modulus E of softening layer (B) may be measured as follows: i) prepare a rectangular sample piece having a width (TD direction) of 10 mm and a length (MD direction) of 100 mm by cutting a film having a thickness of 100 μm ; and ii) measure a tensile elastic modulus of the sample piece using a tension tester in accordance with JIS-K7161 while setting the chuck-to-chuck distance to 50 mm and setting the tensioning rate to 300 mm/min. The measurement of the tensile elastic modulus is performed at 23°C under a relative humidity of 55%. Tensile elastic modulus E is usually three times as large as storage elastic modulus G .

[0030] The resin constituting softening layer (B) is not particularly limited as long as it satisfies the aforementioned condition for the storage elastic modulus. Preferably, softening layer (B) is not made of elastomer. Specifically, the resin constituting softening layer (B) is preferably a homopolymer or copolymer of hydrocarbon olefin, and more preferably, ethylene homopolymer, propylene homopolymer, or a copolymer of ethylene or propylene and a hydrocarbon olefin other than ethylene or propylene. However, ethylene/vinyl acetate copolymer

(EVA) is not preferable, as it typically has storage elastic modulus $G(40)$ at 40°C 0.01 to 0.1 MPa, which is lower than 10 MPa.

[0031] In the copolymer of ethylene or propylene and a hydrocarbon olefin other than ethylene or propylene, the hydrocarbon olefin other than ethylene or propylene is preferably an α -olefin having 3 to 12 carbon atoms. Examples of the α -olefin having 3 to 12 carbon atoms may include propylene, 1-butene, 1-pentene, 3-methyl-1-butene, 1-hexene, 4-methyl-1-pentene, 3-methyl-1-pentene, 1-heptene, 1-octene, 1-decene, and 1-dodecene, with propylene, 1-butene and the like being preferable.

[0032] Specific preferred examples of the resin constituting softening layer (B) may include linear low-density polyethylene (LLDPE), low-density polyethylene, high-density polyethylene, polypropylene, polystyrene, ABS resin, vinyl chloride resin, methyl methacrylate resin, nylon, fluorine resin, polycarbonate, and polyester resin, with linear low-density polyethylene (LLDPE), low-density polyethylene, high-density polyethylene, polypropylene, and the like being preferable.

[0033] The resin constituting softening layer (B) preferably has a density of 880 to 960 kg/m³, more preferably, 900 to 960 kg/m³, and further preferably, 910 to 950 kg/m³. If the resin constituting softening layer (B) has a density lower than 880 kg/m³, softening layer (B) may be softened at 40°C. Meanwhile, the density of the resin exceeds 960 kg/m³, it may be difficult to soften the resin at the thermocompression bonding temperature.

[0034] The storage elastic modulus of softening layer (B) may be

controlled based on the density of the homopolymer of ethylene or propylene, the type and proportion of the hydrocarbon olefin other than ethylene or propylene in the copolymer of ethylene or propylene and a hydrocarbon olefin other than ethylene or propylene, and so forth. For example, the storage elastic modulus of softening layer (B) at 40°C may increase, for example, by increasing a density of the homopolymer of ethylene or propylene, or by increasing the proportion of ethylene or propylene in copolymer between ethylene or propylene and the hydrocarbon olefin other than ethylene or propylene.

[0035] The thickness of softening layer (B) may be set such that a rim can be formed through thermocompression bonding with the semiconductor wafer, and unevenness on a surface of the semiconductor wafer can be buried. For this reason, a thickness of softening layer (B) is preferably larger than the maximum height difference on the patterned surface of the semiconductor wafer, and more preferably, equal to or greater than 1.1 times of the maximum height difference. Specifically, if the height difference is 50 μm , the thickness of softening layer (B) is preferably equal to or greater than 55 μm , and more preferably, equal to or greater than 60 μm . On the other hand, if softening layer (B) is too thick, it is difficult to limit deformation (or bending) of the semiconductor wafer during the grinding in comparison with a case where softening layer (B) is thin, so that damage may easily occur. For this reason, the thickness of softening layer (B) is preferably set to 100 μm or smaller, and more preferably, 70 μm or smaller.

[0036] Softening layer (B) may further contain another resin and/or

additive as necessary. Examples of the additive may include ultraviolet absorbers, anti-oxidants, heat-resistant stabilizers, lubricants, and softeners.

[0037] Adhesive Layer (C)

5 Preferably, the semiconductor wafer surface protection film according to the present invention further includes adhesive layer (C) in order to increase adhesion to the semiconductor wafer. If an adhesive force of adhesive layer (C) is too high, the adhesive deposit may easily remain when the film is separated from the semiconductor
10 wafer. For this reason, adhesive layer (C) preferably has an adhesive force at minimum. Specifically, the adhesive force measured according to JIS-Z0237 is preferably set to 0.1 to 10 N/25 mm.

[0038] The storage elastic modulus of adhesive layer (C) may be set to a level that does not hinder the formation of the raised portion (rim)
15 of softening layer (B).

[0039] The adhesive (main adhesive material) of adhesive layer (C) may be an acrylic adhesive, a silicone adhesive, a rubber adhesive, or the like. Especially, in order to facilitate control of the adhesive force, an acrylic adhesive containing acrylic polymer as the base
20 polymer is preferably employed.

[0040] The adhesive of adhesive layer (C) may be a radiation curable adhesive. Since the adhesive layer formed of the radiation curable adhesive is cured by irradiation with radiation, the adhesive layer can be easily separated from the wafer. The radiation may be ultraviolet
25 radiation, electron beam radiation, infrared radiation, or the like.

[0041] The radiation curable adhesive may contain the main adhesive

material described above, a compound having a carbon-carbon double bond in the molecule thereof, and a radioactive polymerization initiator. Alternatively, the radiation curable adhesive may contain a main adhesive material including a polymer having a carbon-carbon double bond in the molecule thereof as the base polymer and a radioactive polymerization initiator.

[0042] Examples of the compound having a carbon-carbon double bond in the molecule thereof may include trimethylolpropane tri(meth)acrylate, pentaerythritol tri(meth)acrylate, dipentaerythritol hexa(meth)acrylate, and tetraethyleneglycol di(meth)acrylate. The amount of the radiation curable compound may be about 30 parts by weight or lower per 100 parts by weight of adhesive.

[0043] The radioactive polymerization initiator may include an acetophenone-based photosensitive polymerization initiator such as methoxy acetophenone; an α -ketol compound such as 4-(2-hydroxyethoxy)phenyl(2-hydroxy-2-propyl)ketone; a ketal-based compound such as benzil dimethyl ketal; a benzoin-based photosensitive polymerization initiator such as benzoin or benzoin methyl ether; and a benzophenone-based photosensitive polymerization initiator such as benzophenone or benzoylbenzoic acid.

[0044] The radiation curable adhesive may further contain a cross-linking agent as necessary. The cross-linking agent may include an isocyanate-based cross-linking agent such as diphenylmethane diisocyanate, tolylene diisocyanate, hexamethylene diisocyanate, and polyisocyanate.

[0045] The thickness of adhesive layer (C) may be set to a level that

does not hinder the formation of the rim of softening layer (B). For example, the thickness of adhesive layer (C) may be set to 1 to 20% of the thickness of softening layer (B). Specifically, the thickness of adhesive layer (C) may be set to 1 to 20 μm .

5 [0046] Less adhesive layer (D)

The semiconductor wafer surface protection film according to the present invention may include less adhesive layer (D) that allows for separation between base layer (A) and softening layer (B). Examples of less adhesive layer (D) may include acrylic adhesives.

10 [0047] When the semiconductor wafer surface protection film according to the present invention includes less adhesive layer (D), base layer (A) and softening layer (B) can be separated from each other. Therefore, it is possible to separate and remove base layer (A) from the semiconductor wafer surface protection film after attaching the
15 semiconductor wafer surface protection film to the semiconductor wafer. For example, base layer (A) may be separated and removed from the semiconductor wafer surface protection film after the process of forming the raised portion of the semiconductor surface protection film around a circumference of the semiconductor wafer (see Fig. 2C)
20 and before the process of grinding the non-patterned surface of the semiconductor wafer (see Fig. 2E).

[0048] More precise grinding may be achieved when the non-patterned surface of the semiconductor wafer is grinded after separation of base layer (A). It may be difficult to perform precise
25 grinding in cases where the semiconductor wafer surface protection film is bent or vibrated due to the load of the abrasive material during

the grinding of the semiconductor wafer. In this regard, bending or vibration of the semiconductor wafer surface protection film may be limited if the semiconductor wafer is grinded after base layer (A) is separated, and the semiconductor wafer surface protection film is
5 thinned. Therefore, it is possible to implement more accurate grinding.

[0049] The semiconductor wafer surface protection film according to the present invention may further include another layer as necessary. Another layer may be, for example, a releasable film.

10 [0050] As described above, the semiconductor wafer surface protection film includes base layer (A) and softening layer (B). Base layer (A) is preferably the outermost layer of the semiconductor wafer surface protection film. In a case where the semiconductor wafer surface protection film further includes adhesive layer (C), adhesive
15 layer (C) is preferably the outermost layer of the film on the side opposite from base layer (A). Softening layer (B) may be a single layer or a plurality of layers.

[0051] Figs. 1A and 1B are diagrams illustrating an exemplary configuration of the semiconductor wafer surface protection film. As
20 illustrated in Fig. 1A, semiconductor wafer surface protection film 10 includes base layer (A) 12, softening layer (B) 14, and adhesive layer (C) 16. As illustrated in Fig. 1B, semiconductor wafer surface protection film 10' includes base layer (A) 12, less adhesive layer (D) 18, softening layer (B) 14, and adhesive layer (C) 16. Semiconductor
25 wafer surface protection films 10 and 10' are used such that adhesive layer (C) 16 contacts the patterned surface of the semiconductor wafer.

[0052] The semiconductor wafer surface protection film according to the present invention may be manufactured using any method. For example, the semiconductor wafer surface protection film may be manufactured by: 1) coextrusion-molding base layer (A) and softening layer (B) (coextrusion forming method); 2) laminating film-like base layer (A) and film-like softening layer (B) (lamination method); and so forth. The semiconductor wafer surface protection film further including adhesive layer (C) may be manufactured by applying an adhesive layer coating solution on the laminated film including base layer (A) and softening layer (B).

[0053] 2. Method of Manufacturing Semiconductor Device

An exemplary method of manufacturing a semiconductor device using the semiconductor wafer surface protection film according to the present invention includes: 1) disposing a semiconductor wafer on a semiconductor wafer surface protection film (mount process); 2) forming around the circumference of the semiconductor wafer a raised portion of the semiconductor wafer surface protection film for holding the semiconductor wafer (press process); 3) grinding the non-patterned surface of the semiconductor wafer held by the raised portion; and 4) separating the semiconductor wafer surface protection film. The process of grinding the non-patterned surface of the semiconductor wafer held by the semiconductor wafer surface protection film according to the present invention (Process 3) refers to a process of thinning the semiconductor wafer up to a predetermined thickness without causing fracture or damage to the semiconductor wafer. After these processes, a process of dicing the semiconductor wafer into

individual chips may be additionally performed.

[0054] Another exemplary method of manufacturing the semiconductor device using the semiconductor wafer surface protection film includes: 1') preparing a semiconductor wafer; 2') forming a raised portion substantially made of resin around a circumference of the semiconductor wafer); 3') disposing the patterned surface of the semiconductor wafer on the semiconductor wafer surface protection film; 4') grinding the non-patterned surface of the semiconductor wafer held by the raised portion; and 5') separating the semiconductor wafer surface protection film. Any of the process of forming the raised portion (Process 2') or the process of disposing the patterned surface of the semiconductor wafer on the semiconductor wafer surface protection film (Process 3') may be performed first.

[0055] In Process 2', the raised portion substantially made of resin formed around the circumference of the semiconductor wafer may be formed of a resin material different from that of the semiconductor wafer surface protection film. In this case, the semiconductor wafer surface protection film is not limited to the semiconductor wafer surface protection film according to the present invention described above. Instead, a commonly-used semiconductor wafer surface protection film may be employed. Storage elastic modulus $G_B(40)$ of the raised portion substantially made of resin may be equal to or higher than 10 MPa. Preferably, storage elastic modulus $G_B(100)$ is equal to or higher than 1 MPa.

[0056] The combination of a semiconductor wafer and the raised portion (rim) which is disposed around the circumference of the

semiconductor wafer and which is substantially made of resin, which combination is created through Process 2', may be referred to as a rimmed semiconductor wafer. The rimmed semiconductor wafer may include a semiconductor wafer and a raised portion substantially made of resin. Alternatively, the rimmed semiconductor wafer may include a semiconductor wafer, a raised portion substantially made of resin, and a semiconductor wafer surface protection film that supports the semiconductor wafer and the raised portion. The semiconductor wafer surface protection film is attached to the patterned surface of the semiconductor wafer.

[0057] A process of disposing a ring frame (see reference numeral 30 in Fig. 2B) to surround the semiconductor wafer (Process 6') may be further included. The process of disposing the ring frame may be performed before the grinding process (Process 4') after the process of preparing the semiconductor wafer (Process 1'). In addition, the raised portion may be provided in a gap between the ring frame (see reference numeral 30 in Fig. 2B) and the semiconductor wafer.

[0058] In the rimmed semiconductor wafer, a gap between the raised portion and the edge of the semiconductor wafer is preferably set to 0 to 1 mm, and more preferably, 0 to 500 μm . Further preferably, the raised portion contacts the edge of the semiconductor wafer because the raised portion holds the semiconductor wafer.

[0059] The semiconductor wafer is not particularly limited and may be a silicon substrate or a sapphire substrate on which circuits including interconnections, capacitors, diodes or transistors, and the like are formed. By forming a raised portion (rim) around the

circumference of the semiconductor wafer using the semiconductor wafer surface protection film according to the present invention and the like and grinding the non-patterned surface of the wafer, it is possible to limit damages to the semiconductor wafer even when the semiconductor wafer includes a high-hardness substrate having a Mohs' hardness of 8 or higher. In addition, the semiconductor wafer according to the present invention may be obtained by laminating a semiconductor layer such as GaN on a sapphire substrate. In a case where a semiconductor device such as an LED element is manufactured, a sapphire substrate on which circuits are formed is preferably used. A size of the semiconductor wafer may be set to, but not limited to, 2 inches, 4 inches, 6 inches, 8 inches, and the like. The patterned surface of the semiconductor wafer has a height difference of 1 to 50 μm .

[0060] The raised portion (rim) of the semiconductor wafer surface protection film, formed around the semiconductor wafer, is a portion formed around the circumference of the semiconductor wafer and holds the edge portion of the semiconductor wafer. The raised portion of the semiconductor wafer surface protection film may be formed of the semiconductor wafer surface protection film itself or may be made of a material different from that of the semiconductor wafer surface protection film.

[0061] For example, the following method may be used in order to form the raised portion using a resin material different from that of the semiconductor wafer surface protection film. In each method, the semiconductor wafer may be a semiconductor wafer mounted on the

semiconductor wafer surface protection film or may be a semiconductor wafer before it is mounted on the semiconductor wafer surface protection film.

Method 1) apply liquid glue 105 around semiconductor wafer 20 using an applicator such as dispenser 100, as illustrated in Fig. 8A, and cure liquid glue 105;

Method 2) insert semiconductor wafer 20 into resin ring 110 having a through-hole whose diameter is almost the same as that of semiconductor wafer 20, as illustrated in Fig. 8B; and

Method 3) inject molten resin into cavity 125 of mold 120 where semiconductor wafer 20 is fitted, as illustrated in Fig. 8C, and solidify the resin by cooling so as to form the resin around semiconductor wafer 20.

[0062] In Method 1, the viscosity of liquid glue 105 applied using dispenser 100 at the time of application (pre-curing) is preferably set to about 1 to about 500 Pa·s. Cured glue 105 preferably has storage elastic modulus $G_B(40)$ of 10 MPa or higher. In addition, storage elastic modulus $G_B(100)$ is preferably set to 1 MPa or higher. That is, cured glue 105 preferably has the same elastic modulus as that of softening layer (B) of the semiconductor wafer surface protection film described above. Examples of liquid glue 105 may include epoxy resins, acryl resins, urethane resins, and phenol resins.

[0063] In Method 2, resin ring 110 having a through-hole whose diameter is almost the same as that of semiconductor wafer 20 may have storage elastic modulus $G_B(40)$ of 10 MPa or higher. Preferably, resin ring 110 has storage elastic modulus $G_B(100)$ of 1 MPa or higher. That

is, resin ring 110 preferably has the same elastic modulus as that of softening layer (B) of the semiconductor wafer surface protection film described above. Examples of the resin constituting resin ring 110 may include polyethylenes (such as high-density polyethylene and
5 low-density polyethylene), polypropylenes (such as homopolypropylene and random polypropylene), polystyrenes, and nylons.

[0064] In Method 3, the molten resin injected into cavity 125 of mold 120 may be epoxy resin or the like. The molten resin solidified by
10 cooling may have storage elastic modulus $G_B(40)$ of 10 MPa or higher. Preferably, the solidified resin has storage elastic modulus $G_B(100)$ of 1 MPa or higher. That is, the solidified resin preferably has the same elastic modulus as that of softening layer (B) of the semiconductor wafer surface protection film described above.

15 [0065] As described above, the raised portion (rim) around the semiconductor wafer may be formed through any method. However, it is preferable that the raised portion (rim) be formed by performing thermocompression bonding of the semiconductor wafer surface protection film according to the present invention because the raised
20 portion (rim) can be formed relatively easily and from the viewpoint of handling convenience.

[0066] The raised portion preferably has a storage elastic modulus at 100°C ($G(100)$) of 1 MPa or higher. In a case where the raised portion is formed using the semiconductor wafer surface protection film, as
25 described below, the raised portion is formed of softening layer (B) of the aforementioned film. In this case, the storage elastic modulus of

the raised portion is comparable to the storage elastic modulus of softening layer (B). In addition, it is preferable that the raised portion (rim) be substantially formed of relatively flexible resin in order to make it difficult to cause damage when the abrasive material makes contact with the raised portion and cause the abrasive material to effectively make contact with the non-patterned surface of the semiconductor wafer in the rear surface grinding process of the semiconductor wafer described below.

[0067] An exemplary method of manufacturing a semiconductor device using the semiconductor wafer surface protection film according to the present invention will now be described with reference to the accompanying drawings. Fig. 2A is a diagram illustrating an exemplary process of disposing a semiconductor wafer on the semiconductor wafer surface protection film (mount process). Fig. 2B is a diagram illustrating a laminate in which the semiconductor wafer is disposed on the semiconductor wafer surface protection film. Fig. 2C is a diagram illustrating an exemplary process of forming a raised portion of the semiconductor surface protection film around a circumference of the semiconductor wafer (press process). Fig. 2D is an enlarged view illustrating an exemplary raised portion. Fig. 2E is a diagram illustrating an exemplary process of grinding a non-patterned surface of the semiconductor wafer.

[0068] Mount Process

An exemplary process of disposing the semiconductor wafer on the semiconductor wafer surface protection film is illustrated in Fig. 2A. First, semiconductor wafer surface protection film 10 is prepared

that has been cut in a size larger than semiconductor wafer 20. Then, semiconductor wafer 20 is disposed on semiconductor wafer surface protection film 10 (Process 1). In this case, patterned surface 20A of semiconductor wafer 20 contacts adhesive layer (C) 16 of semiconductor wafer surface protection film 10.

[0069] Specifically, semiconductor wafer 20 and ring frame 30 surrounding semiconductor wafer 20 are disposed on hot plate 40. In addition, semiconductor wafer surface protection film 10 is disposed on semiconductor wafer 20 and ring frame 30. In this case, patterned surface 20A of semiconductor wafer 20 makes contact with adhesive layer (C) 16 of semiconductor wafer surface protection film 10.

[0070] Semiconductor wafer surface protection film 10 is firmly pressed against semiconductor wafer 20 while rotating roller 35 across semiconductor wafer 20 from one edge portion to the other. As a result, semiconductor wafer surface protection film 10 firmly abuts patterned surface 20A of semiconductor wafer 20. While semiconductor wafer surface protection film 10 is firmly pressed against semiconductor wafer 20 using roller 35, hot plate 40 may remain at normal temperature. Alternatively, semiconductor wafer surface protection film 10 may be heated to temperature T_M by heating hot plate 40.

[0071] Temperature T_M of semiconductor wafer surface protection film 10 in the mount process is preferably equal to or higher than temperature T_P of semiconductor wafer surface protection film 10 in the process of forming the raised portion of the semiconductor wafer surface protection film around the circumference of the semiconductor

wafer (described below). Although described in detail below, this is because, in some cases, a wrinkle may be generated on semiconductor wafer surface protection film 10 in the process of forming the raised portion, or semiconductor wafer 20 may be separated from semiconductor wafer surface protection film 10 after the process of forming the raised portion.

[0072] After the mount process, semiconductor wafer 20 is separated from hot plate 40 along with semiconductor wafer surface protection film 10 and ring frame 30 so as to obtain a laminate in which the semiconductor wafer is disposed on the semiconductor wafer surface protection film as illustrated in Fig. 2B. This laminate is referred to as a "mount frame."

[0073] Press Process

Next, as illustrated in Fig. 2C, semiconductor wafer 20 and semiconductor wafer surface protection film 10 are thermocompressively bonded using a pair of heating plates (upper and lower heating plates 22-1 and 22-2) of the hot press machine (Process (2)). As a result, semiconductor wafer 20 is pushed into molten softening layer (B) 14, and softening layer (B) 14 extruded forming raised portion (rim) 24 in the vicinity of the edge portion of semiconductor wafer 20. Upper heating plate 22-1 is a heating plate disposed on the semiconductor wafer 20 side, and lower heating plate 22-2 is a heating plate disposed on the semiconductor wafer protection film 10 side. Upper heating plate 22-1 and semiconductor wafer 20 may make direct contact with each other, or may make indirect contact with each other with a member (such as a jig) interposed therebetween.

Similarly, lower heating plate 22-2 and semiconductor wafer protection film 10 may make direct contact with each other, or may make indirect contact with each other with a member (such as a jig) interposed therebetween.

5 [0074] The height of raised portion 24 (rim) is preferably set to, for example, 0.2 to 1 times the thickness of semiconductor wafer 20 subjected to the rear surface grinding. If the height of raised portion (rim) 24 is too small, the edge portion of semiconductor wafer 20 may not be stably held. Specifically, in a case where the rear surface of
10 semiconductor wafer 20 having a thickness of 1,000 μm is to be grinded, the height of raised portion (rim) 24 is preferably set to 200 μm or higher. In addition, although corners of the edge portion of semiconductor wafer 20 are not chamfered in Fig. 2B, a chamfering (straight line) or rounding (curve) process may be performed for the
15 edge portion of semiconductor wafer 20 to remove the corners. In a case where a chamfering (straight line) or rounding (curve) process is performed for the edge portion of semiconductor wafer 20, the height of raised portion (rim) 24 may correspond to the thickness of the edge portion of the semiconductor wafer subjected to the chamfering or
20 rounding process.

[0075] The thermocompression bonding temperature (thermocompression bonding temperature TP) or the pressing pressure may be set such that softening layer (B) 14 is molten to form raised portion (rim) 24. Specifically, the pressing pressure is preferably set
25 to 1 to 10 MPa, and more preferably, 3 to 10 MPa. The pressing time may be set to, for example, 1 to 5 minutes. Thermocompression

bonding temperature TP is preferably set to 120 to 180°C, more preferably, 130 to 170°C, and further preferably, 150°C. Thermocompression bonding temperature TP refers to an average temperature of a pair of heating plates (upper and lower heating plates
5 22-1 and 22-2) of the press machine.

[0076] Furthermore, thermocompression bonding temperature TP is preferably equal to or lower than temperature TM of semiconductor wafer surface protection film 10 in the mount process described above. The semiconductor wafer surface protection film 10 tends to thermally
10 expand due to the heating in the press process. However, if thermocompression bonding temperature TP is equal to or lower than temperature TM of the mount process, a thermal expansion degree of semiconductor wafer surface protection film 10 in the press process becomes equal to or lower than a thermal expansion degree of
15 semiconductor wafer surface protection film 10 in the mount process. Since semiconductor wafer surface protection film 10 subjected to sufficient thermal expansion in the mount process is fixed to the semiconductor wafer, semiconductor wafer surface protection film 10 does not easily thermally expand in the press process, and a wrinkle is
20 not easily generated. Meanwhile, if thermocompression bonding temperature TP and temperature TM are not appropriately controlled, a wrinkle is easily generated in semiconductor wafer surface protection film 10 around semiconductor wafer 20.

[0077] Furthermore, as semiconductor wafer surface protection film
25 10 is cooled after the press process, there are cases where semiconductor wafer surface protection film 10 and semiconductor

wafer 20 may be separated from each other (semiconductor wafer 20 comes off from the film 10) in some cases. Such a separation is limited by setting thermocompression bonding temperature TP to be equal to or lower than temperature TM of the mount process. In this manner, by reducing the occurrence of a wrinkle in the semiconductor surface protection film, it is possible to prevent a fracture of the semiconductor wafer in the process of grinding a rear surface of the semiconductor wafer.

[0078] Thermocompression bonding temperature TP is preferably higher than softening temperature TmB of softening layer (B) of semiconductor wafer surface protection film 10. Setting thermocompression bonding temperature TP to softening temperature TmB or higher makes it easy to soften softening layer (B) and form raised portion (rim) 24. Meanwhile, thermocompression bonding temperature TP is preferably lower than "softening temperature TmB of softening layer (B) of semiconductor wafer surface protection film 10 plus 40°C (TmB + 40°C)." If thermocompression bonding temperature TP is excessively high, it is difficult to hold the shape of raised portion (rim) 24 formed by softening of softening layer (B), and raised portion (rim) 24 may flow and become flattened. As a result, the height of raised portion 24 may be lowered.

[0079] As described above, thermocompression bonding temperature TP refers to an average temperature of a pair of heating plates (upper and lower heating plates 22-1 and 22-2) of a press machine. Temperature TP1 of upper heating plate 22-1 may be equal to temperature TP2 of lower heating plate 22-2. Preferably, temperature

TP1 of upper heating plate 22-1 is higher than temperature TP2 of lower heating plate 22-2. As thermocompression bonding temperature TP increases, raised portion (rim) 24 can be formed rapidly. However, if temperature TP2 of lower heating plate 22-2 is high, it is difficult to retain the shape of raised portion (rim) 24, and raised portion (rim) 24 flows and flattened. Meanwhile, since upper heating plate 22-1 and semiconductor wafer surface protection film 10 do not make direct contact (there is a gap therebetween), the shape of raised portion (rim) 24 is not easily flattened by temperature TP1 of upper heating plate 22-1. In this regard, by setting temperature TP1 of upper heating plate 22-1 to be higher than temperature TP2 of lower heating plate 22-2, it is possible to form raised portion (rim) 24 rapidly while the shape of raised portion (rim) 24 is retained.

[0080] Specifically, it is preferable that temperature TP1 of upper heating plate 22-1 be higher than "softening temperature TmB of softening layer (B) of semiconductor wafer surface protection film 10 plus 20°C (TmB + 20°C)" and be lower than "softening temperature TmB of softening layer (B) of semiconductor wafer surface protection film 10 plus 40°C (TmB + 40°C)." In addition, it is preferable that temperature TP2 of lower heating plate 22-2 be higher than "temperature TP1 of upper heating plate 22-1 minus 40°C (TP1 - 40°C)" and be lower than "temperature TP1 of upper heating plate 22-1." Furthermore, it is preferable that thermocompression bonding temperature TP be higher than "temperature TP1 of upper heating plate 22-1 minus 20°C (TP1 - 20°C)" and be lower than "temperature TP1 of upper heating plate 22-1."

[0081] The height of raised portion (rim) 24 is defined as height h from the surface of semiconductor wafer surface protection film 10 contacting the patterned surface of semiconductor wafer 20 to the apex of raised portion (rim) 24 as illustrated in Fig. 2D. The height of raised portion (rim) 24 may be measured visually by observing the cross-sectional shape of semiconductor wafer surface protection film 10 using a microscope after separating semiconductor wafer 20.

[0082] Raised portion (rim) 24 does not necessarily contact the edge portion of semiconductor wafer 20. However, in order to increase the capability of holding semiconductor wafer 20, raised portion 24 preferably contacts the edge portion of semiconductor wafer 20.

[0083] Semiconductor wafer surface protection film 10 is then loaded on chuck table 26 together with semiconductor wafer 20 as illustrated in Fig. 2E. As described above, the semiconductor wafer surface protection film may include less adhesive layer (D) provided between base layer (A) and softening layer (B) (see Fig. 1B). In a case where there is less adhesive layer (D) provided, semiconductor wafer surface protection film 10 may be loaded on chuck table 26 after removing base layer (A).

[0084] In addition, non-patterned surface (rear surface) 20B of the semiconductor wafer is grinded using abrasive material 28 until the thickness of the wafer becomes a predetermined value or smaller (Process (3)). The thickness of the semiconductor wafer subjected to the rear surface grinding may be set to, for example, 300 μm or smaller, and preferably, 100 μm or smaller. The grinding process is a mechanical grinding process using an abrasive material. The mode of

grinding is not particularly limited; grinding may be effected based on well-known modes such as through-feed mode or in-feed mode. The grinding process may further include dry grinding (dry polishing) in addition to wet grinding (wet polishing).

5 [0085] Then, semiconductor wafer surface protection film 10 is separated at normal temperature (Process (4)). The semiconductor wafer surface protection film 10 may be separated using for example a tape stripper known in the art. In addition, in a case where semiconductor wafer surface protection film 10 includes radiation
10 curable adhesive layer (C), adhesive layer (C) is cured by directing radiation onto semiconductor wafer surface protection film 10, and semiconductor wafer surface protection film 10 is separated from semiconductor wafer 20.

[0086] Between the process of performing rear surface grinding for
15 the semiconductor wafer (Process (3)) and the process of separating the semiconductor wafer surface protection film from the semiconductor wafer (Process (4)), a process of processing the non-patterned surface (rear surface) of the semiconductor wafer may be included as necessary. In addition to the process of processing the non-patterned surface (rear
20 surface) of the semiconductor wafer, another process selected from a group consisting of, for example, a metal sputtering process, a plating process, and a heating process may be further included. The heating process may be a process of attaching, for example, a die-bonding tape by heating. Then, the semiconductor wafer is diced. Alternatively,
25 the semiconductor wafer may be diced without separating semiconductor wafer surface protection film 10.

[0087] By performing thermocompression bonding between the semiconductor wafer surface protection film according to the present invention and the semiconductor wafer under a predetermined condition, it is possible to form a raised portion (rim) of the semiconductor wafer surface protection film around the circumference of the semiconductor wafer. In addition, since the raised portion (rim) formed of the semiconductor wafer surface protection film according to the present invention is not molten even at a temperature that the semiconductor wafer reaches during rear surface grinding (about 40°C), the rim's shape can be retained appropriately. For this reason, it is possible to stably hold edge portion of the semiconductor wafer by means of raised portion and thus limit damage to the edge portion of the semiconductor wafer, which is caused by contact with the abrasive material during the rear surface grinding of the semiconductor wafer. Therefore, even when the semiconductor wafer is a hard, fragile sapphire wafer, it is possible to perform rear surface grinding without causing damages to the wafer.

[0088] In addition, in a case where the semiconductor wafer surface protection film includes radiation curable adhesive layer (C), it is possible to easily separate the semiconductor wafer surface protection film by irradiating a radiation onto the semiconductor wafer surface protection film. In this manner, unlike the wax-based method known in the art, it is not necessary to wash out wax resin from the semiconductor wafer, allowing for simplification of the process.

[0089] Another Embodiment of Mount Process

As described above, in the mount process, semiconductor wafer

20 is disposed inside ring frame 30 having a rim, and semiconductor wafer surface protection film 10 is attached over one surface of semiconductor wafer 20 (typically, surface 20A where circuits are formed) and ring frame 30 (see Fig. 2A). In this case, if a gap between ring frame 30 and semiconductor wafer 20 disposed inside ring frame 30 is large, the semiconductor wafer surface protection film between semiconductor wafer 20 and ring frame 30 may be loosened. For this reason, it is preferable that ring-like supporting member 50 be disposed between ring frame 30 and semiconductor wafer 20 (see Figs. 5A and 5B).

[0090] Outer diameter DW of semiconductor wafer 20, inner diameter DA_{IN} of ring frame 30, ring outer diameter DB_{OUT} of ring-like supporting member 50, and ring inner diameter DB_{IN} of ring-like supporting member 50 satisfy the relationship of Equation (1): $DW < DB_{IN} < DB_{OUT} < DA_{IN}$ (see Fig. 5A).

[0091] It is preferable that both the gap between semiconductor wafer 20 and ring-like supporting member 50 and the gap between ring-like supporting member 50 and ring frame 30 be set as small as possible in order to further prevent loosening of attached semiconductor wafer surface protection film 10. That is, difference $\Delta D1$ between outer diameter DW of semiconductor wafer 20 and ring inner diameter DB_{IN} of ring-like supporting member 50 is preferably within 1% of outer diameter DW of semiconductor wafer 20. Similarly, difference $\Delta D2$ between ring outer diameter DB_{OUT} of ring-like supporting member 50 and inner diameter DA_{IN} of ring frame 30 is preferably within 1% of outer diameter DW of semiconductor wafer 20.

$$\Delta D1 = DB_{IN} - DW \quad (2)$$

$$\Delta D2 = DA_{IN} - DB_{OUT} \quad (3)$$

[0092] The mount process may be performed using a semiconductor wafer mounter. The semiconductor wafer mounter includes a heating unit, a tape attaching unit, and a tape cutting mechanism.

[0093] The heating unit is, for example, hot plate 40 where a pre-mount frame is to be disposed. The pre-mount frame is a structure including semiconductor wafer 20, ring-like supporting member 50 surrounding the semiconductor wafer, and ring frame 30 surrounding ring-like supporting member 50 (Fig. 5A). The pre-mount frame is disposed on hot plate 40 such that the surface (non-patterned surface) opposite to patterned surface 20A of semiconductor wafer 20 faces hot plate 40.

[0094] While semiconductor wafer 20 of the pre-mount frame disposed on hot plate 40 is heated using hot plate 40, the tape attaching unit attaches semiconductor wafer surface protection film 10 over patterned surface 20A of semiconductor wafer 20, ring-like supporting member 50, and ring frame 30. The tape attaching unit includes, for example, roller 35, which can roll across patterned surface 20A of semiconductor wafer 20, ring-like supporting member 50, and ring frame 30.

[0095] The tape cutting mechanism cuts semiconductor wafer surface protection film 10 along an outer diameter of the ring frame before or after semiconductor wafer surface protection film 10 is attached to the pre-mount frame. The tape cutting mechanism may be a cutter and the like (not illustrated). In this manner, the mount frame including

semiconductor wafer 20, ring-like supporting member 50, ring frame 30, and semiconductor wafer surface protection film 10 is obtained.

[0096] Another Embodiment of Press Process

As described above, the press process is a process of pressing the mount frame obtained through the mount process using a pair of press plates (upper and lower press plates 22-1 and 22-2) (see Fig. 2C). However, as a pressure caused by upper and lower heating plates 22-1 and 22-2 is released after the press process, the outer circumference portion of semiconductor wafer surface protection film 10 of the mount frame may become thinner than the center portion as illustrated in Fig. 6. It is conceived that this is because the outer circumference portion of semiconductor wafer surface protection film 10 of the mount frame flows outwardly, but the center portion does not easily flow during the press process.

[0097] In this regard, out of a pair of press plates, lower press plate 22-2 preferably has protrusion 60 on a surface facing upper press plate 22-1. Protrusion 60 provided in lower press plate 22-2 intrudes into semiconductor wafer protection film 10 during the press (Fig. 7A). For this reason, it is possible to uniformize the thickness of semiconductor wafer surface protection film 10 of the mount frame subjected to the press process and also form raised portion (rim) 24.

[0098] The circumference (circumferential edge) of the surface of protrusion 60 of lower press plate 22-2 making contact with the semiconductor wafer protection film preferably has a circular shape. Accordingly, protrusion 60 may have a conical shape (Fig. 7B) or a dome-like shape (Fig. 7C).

[0099] The height of protrusion 60 of lower press plate 22-2 is preferably set to 1 to 100 μm , and more preferably, within 15 to 100% of the thickness of softening layer (B) of semiconductor wafer surface protection film 10. The height of protrusion 60 refers to the maximum height of protrusion 60.

[0100] Diameter CD of protrusion 60 of lower press plate 22-2 is greater than outer diameter DW of the semiconductor wafer of the mount frame and smaller than inner diameter DA_{IN} of the ring frame. That is, a relationship of $DW < CD < DA_{\text{IN}}$ is satisfied.

[0101] The material of protrusion 60 is not particularly limited. Protrusion 60 may be made of a material suitable for grinding to make a convex shape. For example, ceramics such as alumina or ultrahard alloy such as tungsten carbide may be employed.

[0102] The press process may be performed using a semiconductor wafer press apparatus. The semiconductor wafer press apparatus includes upper press plate 22-1 having a heating mechanism and lower press plate 22-2 having protrusion 60 on a surface facing upper press plate 22-1. First, in the press process, the mount frame obtained through the mount process is disposed between upper and lower press plates 22-1 and 22-2. In this case, semiconductor wafer 20 of the mount frame faces upper press plate 22-1, and semiconductor wafer surface protection film 10 of the mount frame faces lower press plate 22-2.

[0103] The mount frame to be disposed has a structure including semiconductor wafer 20, ring frame 30, and semiconductor wafer surface protection film 10 as illustrated in Fig. 7A (see Fig. 2B).

[0104] After disposing the mount frame, the mount frame is heated using a heating mechanism of upper press plate 22-1. In addition, the mount frame interposed between upper and lower press plates 22-1 and 22-2 is pressed by upper and lower press plates 22-1 and 22-2.

5 [0105] By separating the mount frame from upper and lower press plates 22-1 and 22-2, it is possible to form a raised portion (rim) in the semiconductor wafer surface protection film and make uniform the thickness of the semiconductor wafer surface protection film subjected to the press process.

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Examples

[0106] Example 1

Preparation of Materials

As the material of base layer (A), homopolypropylene (hPP) (produced by Prime Polymer Co., Ltd.) having a density of 910 kg/m^3 was prepared. As the material of softening layer (B), linear low-density polyethylene (LLDPE) (produced by Prime Polymer Co., Ltd.) having a density of 918 kg/m^3 was prepared. As the material of adhesive layer (C), an adhesive layer coating solution was prepared as follows.

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[0107] Preparation of Adhesive Layer Coating Solution

A monomer mixture of ethyl acrylate (30 parts by weight), 2-ethylhexyl acrylate (40 parts by weight), methyl acrylate (10 parts by weight), and glycidyl methacrylate (20 parts by weight) was reacted in toluene (65 parts by weight) and ethyl acetate (50 parts by weight) at 80°C for 10 hours using 0.8 parts by weight of a

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benzoyl-peroxide-based polymerization initiator (NIPER BMT-K40, produced by NOF CORPORATION) of (0.32 parts by weight as an initiator). After completing the reaction, the obtained solution was cooled, and then, a reaction was performed by adding xylene (100 parts by weight), acrylic acid (10 parts by weight), and tetradecyl dimethyl benzil ammonium chloride (CATION M2-100, produced by NOF CORPORATION) (0.3 parts by weight) and by blowing air at 85°C for 50 hours. As a result, an acrylic adhesive polymer solution (main adhesive agent) was obtained.

[0108] To the obtained acrylic adhesive polymer solution (main adhesive agent), 2 parts by weight of benzil dimethyl ketal (IRGACURE 651, produced by Nihon Ciba-Geigy K., K.) were added as an intramolecular bond cleavage type photosensitive polymerization initiator, and a mixture of dipentaerythritol hexaacrylate and dipentaerythritol monohydroxy pentaacrylate (ARONIX M-400, produced by TOAGOSEI CO., LTD.) (0.3 parts by weight) was added as a monomer having a polymerizable carbon-carbon double bond in its molecule for the acrylic adhesive polymer solid content of 100 parts by weight. In addition, 1.35 parts by weight of an isocyanate-based crosslinking agent (OLESTER P49-75-S, produced by Mitsui Chemicals, Inc.) (1 parts by weight as a thermal cross-linking agent) was added as a thermal cross-linking agent to obtain an UV-curable adhesive. The adhering force of the obtained UV-curable adhesive was measured in accordance with JIS-Z0237, and the result was 3 N/25 mm.

[0109] 1) Measurement of Storage Elastic Modulus

Extrusion molding was performed for homo polypropylene (hPP)

(produced by Prime Polymer Co., Ltd.) having a density of 910 kg/m^3 and serving as base layer (A) to obtain a sample film having a thickness of $500 \text{ }\mu\text{m}$. Similarly, extrusion molding was performed for linear low-density polyethylene (LLDPE) (produced by Prime Polymer Co., Ltd.) having a density of 918 kg/m^3 and serving as softening layer (B) to obtain a sample film having a thickness of $500 \text{ }\mu\text{m}$. The aforementioned UV-curable adhesive serving as adhesive layer (C) was coated on a glass substrate. The adhesive was dried and then separated so that a sample film having a thickness of $300 \text{ }\mu\text{m}$ was manufactured.

[0110] A storage elastic modulus of the sample film was measured through the following method. That is, the sample film was set on a dynamic viscoelasticity test station (ARES series rheometer, produced by TA INSTRUMENTS, Inc.), and a storage elastic modulus was measured by increasing a temperature up to 200°C at a rate of $3^\circ\text{C}/\text{min}$. from 30°C using a parallel plate type attachment having a diameter of 8 mm . A measurement frequency was set to 1 Hz . After terminating the measurement, for each of sample films of base layer (A) and softening layer (B), the storage elastic moduluses at temperatures of 40°C , 100°C , and 150°C were read from the obtained storage elastic modulus/temperature curve within a temperature range of 10 to 200°C . For the sample film of adhesive layer (C), the storage elastic modulus at 25°C was read from the obtained storage elastic modulus/temperature curve within a temperature range of 10 to 200°C .

[0111] Manufacturing of Semiconductor Wafer Surface Protection Film

Coextrusion was performed for homo polypropylene (hPP) (produced by Prime Polymer Co., Ltd.) having a density of 910 kg/m^3 and serving as base layer (A) and linear low-density polyethylene (LLDPE) (produced by Prime Polymer Co., Ltd.) having a density of 918 kg/m^3 and serving as softening layer (B) to obtain a two-layered coextrusion film. The aforementioned UV-curable adhesive was applied to softening layer (B) of the obtained coextrusion film and was then dried to form adhesive layer (C), so that the semiconductor wafer surface protection film was obtained. The thicknesses of base layer (A), softening layer (B), and adhesive layer (C) of the semiconductor wafer surface protection film were $60 \text{ }\mu\text{m}$, $70 \text{ }\mu\text{m}$, and $5 \text{ }\mu\text{m}$, respectively, and a total thickness was $135 \text{ }\mu\text{m}$.

[0112] 2) Evaluation of Formability of Raised Portion (Rim)

The obtained semiconductor wafer surface protection film was cut in a size larger than that of the sapphire wafer. Then, a sapphire wafer having a thickness of $650 \text{ }\mu\text{m}$ and a size of 4 inches was disposed on the semiconductor wafer surface protection film. In this case, the patterned surface of the sapphire wafer contacts adhesive layer (C) of the semiconductor wafer surface protection film. These materials are set on a hot press machine, and thermocompression bonding was performed at 140°C under a pressure of 10 MPa for 2 minutes.

[0113] Then, ultraviolet rays ($1,000 \text{ mJ}$) were directed onto the semiconductor wafer surface protection film, and the semiconductor wafer surface protection film was separated from the semiconductor wafer. A cross-section of the obtained semiconductor wafer surface protection film was observed with a microscope. The heights of two

raised portions (rims) were measured in the cross section of the semiconductor wafer surface protection film, and an average of the measured values of height was obtained. As the height of the raised portion (rim), the height of the apex of the raised portion (rim) with respect to the surface of semiconductor wafer surface protection film contacting the patterned surface of the semiconductor wafer was measured. The formability of the raised portion (rim) was evaluated based on the following criteria.

o: height of the raised portion (rim) is equal to or higher than 200 μm ; and

x: height of the raised portion (rim) is lower than 200 μm .

[0114] 3) Evaluation of Rear Surface Grinding Availability

As described above, the obtained semiconductor wafer surface protection film was cut in a size larger than that of the sapphire wafer. Then, a sapphire wafer having a thickness of 650 μm and a size of 4 inches was disposed on the semiconductor wafer surface protection film. These materials were set on a hot press machine, and thermocompression bonding was performed at 140°C under a pressure of 10 MPa for 2 minutes.

20 [0115] Availability of 90 μm Rear Surface Grinding

The semiconductor wafer surface protection film and the sapphire wafer subjected to thermocompression bonding were set on a chuck table of a grinder/polisher (DGP8761, produced by DISCO Corporation), and the non-patterned surface (rear surface) of the sapphire wafer was grinded in a wet type until the wafer thickness reaches 90 μm . The wafer temperature for grinding was at about 40°C.

Then, the rear surface grinding availability was evaluated based on the following criteria.

o: rear surface grinding can be performed until the wafer thickness reaches 90 μm ; and

5 x: the substrate is fractured before the wafer thickness reaches 90 μm (rear surface grinding is not possible).

[0116] Availability of 70 μm Rear Surface Grinding

The sapphire wafer subjected to the rear surface grinding until the wafer thickness reaches 90 μm was further grinded in a wet type
10 until the wafer thickness reaches 70 μm . Then, the rear surface grinding availability was evaluated based on the following criteria.

o: rear surface grinding can be performed until the wafer thickness reaches 70 μm ; and

x: the substrate is fractured before the wafer thickness reaches
15 70 μm (rear surface grinding is not allowable).

[0117] 4) Evaluation of Configuration of Raised Portion Subjected to Dry Polishing (DP)

Dry grinding (dry polishing) was performed on the sample subjected to wet rear surface grinding in the above-described section 3)
20 for another 5 minutes. A wafer temperature at the time of dry polishing was about 100°C. In addition, ultraviolet rays (1,000 mJ) were directed onto the semiconductor wafer surface protection film, and then the sapphire wafer was separated from the semiconductor wafer surface protection film. The height of the raised portion (rim)
25 was measured visually by observing the cross section of the obtained semiconductor wafer surface protection film with a microscope. Heat

resistance in dry polishing (DP) was evaluated based on the following criteria.

o: the height of the raised portion (rim) nearly corresponds with a thickness of the wafer subjected to the grinding (rim remains without being molten); and

x: the height of the raised portion (rim) is lower than the thickness of the wafer subjected to the grinding (rim is molten and lost).

[0118] 5) Surface Smoothness of Base Layer (A) Subjected to Grinding

Surface smoothness of base layer (A) subjected to the dry grinding (dry polishing) in the aforementioned *paragraph 4*) was evaluated using a stylus profilometer (Dektac3, produced by Veeco Instruments, Inc.). The evaluation of surface smoothness was performed based on the following criteria.

o: the surface roughness Ra of base layer (A) caused by surface shape transfer on the chuck table is lower than 1 μm ; and

x: the surface roughness Ra of base layer (A) caused by surface shape transfer on the chuck table is equal to or higher than 1 μm .

Example 2

[0119] The semiconductor wafer surface protection film was manufactured through processes similar to those of Example 1 except that each of the thicknesses of base layer (A) and softening layer (B) was changed to 30 μm , and similar evaluations were performed.

Example 3

[0120] The semiconductor wafer surface protection film was manufactured through processes similar to those of Example 1 except that a material of softening layer (B) was changed to ethylene- α -olefin copolymer (TAFMER, produced by Mitsui Chemicals, Inc.) having a density of 893 kg/m³, and similar evaluations were performed.

Example 4

[0121] The semiconductor wafer surface protection film was manufactured through processes similar to those of Example 1 except that a material of softening layer (B) was changed to linear low-density polyethylene (LLDPE) (produced by Prime Polymer Co., Ltd.) having a density of 938 kg/m³, and each of the thicknesses of base layer (A) and softening layer (B) is changed to 30 μ m, and similar evaluations were performed.

Example 5

[0122] The semiconductor wafer surface protection film was manufactured through processes similar to those of Example 1 except that a material of softening layer (B) was changed to random polypropylene (rPP) (produced by Prime Polymer Co., Ltd.) having a density of 910 kg/m³, and each of the thicknesses of base layer (A) and softening layer (B) was changed to 30 μ m, and similar evaluations were performed.

Comparative Example 1

[0123] The semiconductor wafer surface protection film was manufactured through processes similar to those of Example 1 except that a material of base layer (A) was changed to random polypropylene (rPP) (produced by Prime Polymer Co., Ltd.) having a density of 910 kg/m³, and a material of softening layer (B) was changed to ethylene- α -olefin copolymer (TAFMER, produced by Mitsui Chemicals, Inc.) having a density of 893 kg/m³, and similar evaluations were performed.

10 Comparative Example 2

[0124] The semiconductor wafer surface protection film was manufactured through processes similar to those of Example 1 except that a material of base layer (A) was changed to linear low-density polyethylene (LLDPE) (produced by Prime Polymer Co., Ltd.) having a density of 918 kg/m³, and a material of softening layer (B) was changed to ethylene- α -olefin copolymer (TAFMER, produced by Mitsui Chemicals, Inc.) having a density of 893 kg/m³, and similar evaluations were performed.

20 Comparative Example 3

[0125] The semiconductor wafer surface protection film was manufactured through processes similar to those of Example 1 except that a material of base layer (A) was changed to linear low-density polyethylene (LLDPE) (produced by Prime Polymer Co., Ltd.) having a density of 918 kg/m³, and a material of softening layer (B) was changed to ethylene- α -olefin copolymer (TAFMER, produced by Mitsui

Chemicals, Inc.) having a density of 861 kg/m^3 , and similar evaluations were performed.

Comparative Example 4

5 [0126] The semiconductor wafer surface protection film was manufactured through processes similar to those of Example 1 except that the material of softening layer (B) was changed to ethylene- α -olefin copolymer (TAFMER, produced by Mitsui Chemicals, Inc.) having a density of 861 kg/m^3 , and each of the thicknesses of base
10 layer (A) and softening layer (B) is changed to $30 \text{ }\mu\text{m}$, and similar evaluations were performed.

[0127] The storage elastic moduluses of the sample films and evaluation results for the semiconductor wafer surface protection films obtained through Examples 1 to 5 and Comparative Examples 1 to 4 are
15 given in Tables 1 to 3.

Table 1

			Example 1	Example 2	Example 3
Base layer (A)	Material		hPP	hPP	hPP
	Storage elastic modulus G _A (Pa)	40°C	2.4E+08	2.4E+08	2.4E+08
		100°C	5.6E+07	5.6E+07	5.6E+07
		150°C	4.7E+06	4.7E+06	4.7E+06
	Density (kg/m ³)		910	910	910
	MFR (g/10min)		7	7	7
	Thickness (μm)		60	30	60
Softening layer (B)	Material		LLDPE	LLDPE	Ethylene-α-olefin copolymer
	Tensile elastic modulus E _B (Pa)	25°C	1.3E+08	1.3E+08	4.9E+07
		60°C	5.3E+07	5.3E+07	1.4E+07
	Storage elastic modulus G _B (Pa)	40°C	9.3E+07	9.3E+07	1.0E+07
		100°C	8.4E+06	8.4E+06	3.5E+04
		150°C	6.2E+03	6.2E+03	5.5E+03
	E _B (60)/E _B (25)		0.41	0.41	0.29
	Density (kg/m ³)		918	918	893
	MFR (g/10min)		3.8	3.8	6.7
Thickness (μm)		70	30	70	
Adhesive layer (C)	Material		UV-curable adhesive	UV-curable adhesive	UV-curable adhesive
	Storage elastic modulus G _C (Pa)	25°C	9.0E+04	9.0E+04	9.0E+04
	Peel strength (N/25mm)		3	3	3
	Thickness (μm)		5	5	5
Total thickness (μm)			135	65	135
Evaluation	Thermal press condition	Temperature (°C)	140	140	110
		Pressure (MPa)	10	10	10
		Time (minute)	2	2	2
	Formability of raised portion subjected to thermal press		○	○	○
	Rear surface grinding availability (@40°C)	90μm	○	○	○
		70μm	x	○	x
	Configuration of raised portion subjected to DP(@100°C)		○	○	x
	Surface smoothness of base layer subjected to grinding		○	○	○

Table 2

			Example 4	Example 5	Comparative Example 1
Base layer (A)	Material		hPP	hPP	rPP
	Storage elastic modulus G _A (Pa)	40°C	2.4E+08	2.4E+08	2.6E+08
		100°C	5.6E+07	5.6E+07	5.1E+07
		150°C	4.7E+06	4.7E+06	1.8E+04
	Density (kg/m ³)		910	910	910
	MFR (g/10min)		7	7	7
	Thickness (μm)		30	30	60
Softening layer (B)	Material		LLDPE	rPP	Ethylene-α-olefin copolymer
	Tensile elastic modulus E _B (Pa)	25°C	5.5E+08	7.7E+08	4.9E+07
		60°C	1.7E+08	2.6E+08	1.4E+07
	Storage elastic modulus G _B (Pa)	40°C	1.1E+09	2.6E+08	1.0E+07
		100°C	4.1E+07	5.1E+07	3.5E+04
		150°C	8.5E+03	1.8E+04	5.5E+03
	E _B (60)/E _B (25)		0.31	0.33	0.29
	Density (kg/m ³)		938	910	893
	MFR (g/10min)		3.8	7	6.7
Thickness (μm)		30	30	70	
Adhesive layer (C)	Material		UV-curable adhesive	UV-curable adhesive	UV-curable adhesive
	Storage elastic modulus G _C (Pa)	25°C	9.0E+04	9.0E+04	9.0E+04
	Peel strength (N/25mm)		3	3	3
	Thickness (μm)		5	5	5
Total thickness (μm)			65	65	135
Evaluation	Thermal press condition	Temperature (°C)	150	165	110
		Pressure (MPa)	10	10	10
		Time (minute)	2	2	2
	Formability of raised portion subjected to thermal press		○	○	○
	Rear surface grinding availability (@40°C)	90μm	○	○	○
		70μm	○	○	x
	Configuration of raised portion subjected to DP (@100°C)		○	○	x
	Surface smoothness of base layer subjected to grinding		○	○	Δ

Table 3

			Comparative Example 2	Comparative Example 3	Comparative Example 4
Base layer (A)	Material		LLDPE	LLDPE	hPP
	Storage elastic modulus G_A (Pa)	40°C	9.3E+07	9.3E+07	2.4E+08
		100°C	8.4E+06	8.4E+06	5.6E+07
		150°C	6.2E+03	6.2E+03	4.7E+06
	Density (kg/m ³)		918	918	910
	MFR (g/10min)		3.8	3.8	7
	Thickness (μm)		60	60	30
Softening layer (B)	Material		Ethylene-α-olefin copolymer	Ethylene-α-olefin copolymer	Ethylene-α-olefin copolymer
	Tensile elastic modulus E_B (Pa)	25°C	4.9E+07	5.5E+6	5.5E+6
		60°C	1.4E+07	1.6E+5	1.6E+5
	Storage elastic modulus G_B (Pa)	40°C	1.0E+07	8.0E+05	8.0E+05
		100°C	3.5E+04	4.7E+04	4.7E+04
		150°C	5.5E+03	9.6E+03	9.6E+03
	$E_B(60)/E_B(25)$		0.29	<0.1	<0.1
	Density (kg/m ³)		893	861	861
	MFR (g/10min)		6.7	5.3	5.3
Thickness (μm)		70	70	30	
Adhesive layer (C)	Material		UV-curable adhesive	UV-curable adhesive	UV-curable adhesive
	Storage elastic modulus G_C (Pa)	25°C	9.0E+04	9.0E+04	9.0E+04
	Peel strength (N/25mm)		3	3	3
	Thickness (μm)		5	5	5
Total thickness (μm)			135	135	65
Evaluation	Thermal press condition	Temperature (°C)	110	80	80
		Pressure (MPa)	10	10	10
		Time (minute)	2	2	2
	Formability of raised portion subjected to thermal press		○	○	○
	Rear surface grinding availability (@40°C)	90μm	○	x	x
		70μm	x	x	x
	Configuration of raised portion subjected to DP (@100°C)		x	x	x
	Surface smoothness of base layer subjected to grinding		x	x	○

[0128] As shown in Tables 1 and 2, it is recognized that the raised portion (rim) can be appropriately formed through a thermal press using the semiconductor wafer surface protection film of Examples 1 to 5 in which storage elastic modulus at 40°C ($G_B(40)$) of softening layer (B)

is equal to or higher than 10 MPa, and the wafer is not damaged even during the rear surface grinding. It is conceived that this is because the raised portion (rim) is not molten, and the edge portion of the wafer can be stably held even during the rear surface grinding.

5 [0129] In contrast, in the semiconductor wafer surface protection film of Comparative Examples 3 and 4 in which a storage elastic modulus at 40°C ($G_B(40)$) of softening layer (B) is lower than 10 MPa, it is recognized that the wafer is damaged during the rear surface grinding although the raised portion (rim) can be formed through the thermal
10 press. It is conceived that this is because the raised portion (rim) is softened even during the rear surface grinding so that it is difficult to stably hold the edge portion of the wafer.

[0130] Out of Examples 1 to 5, while the wafer of Example 3 is fractured in the 70 μm grinding, the wafer of Example 2 is not fractured
15 even in the 70 μm grinding. It is conceived that this is because storage elastic modulus at 40°C ($G_B(40)$) of softening layer (B) of the semiconductor wafer surface protection film of Example 2 is higher than that of the semiconductor wafer surface protection film of Example 3. In addition, it is conceived that the wafer of Example 1 is
20 fractured in the 70 μm grinding because the semiconductor wafer surface protection film is too thick relative to the wafer finish thickness so that it is difficult to limit deformation (deflection or bending) of the semiconductor wafer.

[0131] In the semiconductor wafer surface protection films of
25 Examples 1 and 2, it is recognized that the raised portion (rim) is not softened even at a high temperature of about 100°C during the dry

polishing (DP), and the edge portion of the sapphire wafer can be stably held.

[0132] In Comparative Examples 1 to 3, it is recognized that the surface smoothness of base layer (A) subjected to the grinding is low.

5 It is conceived that this is because base layer (A) of the semiconductor wafer surface protection film of Comparative Examples 1 to 3 has storage elastic modulus at 150°C ($G_A(150)$) lower than 1 MPa, and a surface shape of the chuck table is transferred during rear surface grinding. If the surface shape of the chuck table is transferred to the
10 surface of base layer (A) during rear surface grinding in this manner, leakage of air may be easily generated between the chuck table and base layer (A) of the semiconductor wafer surface protection film when the semiconductor wafer surface protection film is fixed to another chuck table in the subsequent dicing process. If such leakage of air is
15 generated, the semiconductor wafer surface protection film is not fixed to the chuck table, which is not desirable.

Example 6

[0133] A raised portion (rim) was formed by attaching the same film
20 as that of Example 2 to a sapphire wafer (mount process) and performing thermocompression bonding (press process).

[0134] Specifically, the semiconductor wafer surface protection film was cut in a size larger than that of the sapphire wafer. In addition, the sapphire wafer having a thickness of 650 μm and a size of 4 inches
25 was prepared. The sapphire wafer was disposed on the semiconductor wafer surface protection film as illustrated in Fig. 2A. The hot plate

was heated up to 140°C, and the semiconductor wafer surface protection film was compressively bonded to the sapphire wafer using a roller, so that a laminate including the sapphire wafer and the semiconductor wafer surface protection film was obtained. The roller pressure was set to 0.5 MPa, and the roller speed was set to 10 mm/sec.

[0135] As illustrated in Fig. 2C, the obtained laminate was then interposed between the upper heating plate (heating plate disposed in the semiconductor wafer surface protection film) and the lower heating plate (heating plate disposed in the sapphire wafer side) of the hot press machine, and compressive bonding was performed with a pressure of 10 MPa for 180 seconds. In this case, the temperature of the upper heating plate was set to 140°C, and the temperature of the lower heating plate was set to 120°C, so that average temperature TP thereof was set to 130°C.

[0136] Ultraviolet rays (1,000 mJ) were directed onto the semiconductor wafer surface protection film, and then the semiconductor wafer surface protection film was separated from the sapphire wafer. A cross section of the obtained semiconductor wafer surface protection film was observed with a microscope. The heights of two raised portions (rims) were measured in the cross section of the semiconductor wafer surface protection film, and an average of the measured values of height was obtained.

[0137] 1. Tension in Radial Direction

After the press process, a weight (50 g) was applied to the center of the sapphire wafer, and a film sinking degree was measured while the semiconductor wafer surface protection film was attached to the ring

frame. If the film sinking degree is equal to or greater than 2 mm, it was evaluated that there is no sufficient tension, and this case was marked as "x."

[0138] 2. Wrinkle

5 If, through visual inspection, 10 or more radial wrinkles are observed from the semiconductor wafer surface protection film around the sapphire wafer after the press process, this case was marked as "x."

[0139] 3. Film separation after 48 hours

After the press process, the laminate was disposed at normal
10 temperature for 48 hours while the semiconductor wafer surface protection film was attached to the sapphire wafer. Then, if a separation of 1 mm or larger is observed between the wafer surface protection film and the edge portion of the sapphire wafer, this case was marked as "x."

15

Example 7

[0140] A raised portion (rim) was formed by attaching the same film as that of Example 2 to the sapphire wafer (mount process) and performing thermocompression bonding (press process). Specifically,
20 the semiconductor wafer surface protection film was cut in a size larger than that of the sapphire wafer. In addition, a sapphire wafer having a thickness of 650 μm and a size of 4 inches was prepared. The sapphire wafer was disposed on the semiconductor wafer surface protection film as illustrated in Fig. 2A. The hot plate was heated to 100°C, and the
25 semiconductor wafer surface protection film was compressively bonded to the sapphire wafer using a roller, so that a laminate including the

sapphire wafer and the semiconductor wafer surface protection film was obtained. The roller pressure was set to 0.5 MPa, and the roller speed was set to 10 mm/sec.

[0141] As illustrated in Fig. 2C, the obtained laminate was then
5 interposed between the upper heating plate (heating plate disposed in the semiconductor wafer surface protection film) and the lower heating plate (heating plate disposed in the sapphire wafer side) of the hot press machine, and compressive bonding was performed with a pressure of 10 MPa for 180 seconds. In this case, the temperature of the upper
10 heating plate was set to 140°C, and the temperature of the lower heating plate was set to 120°C, so that average temperature TP thereof was set to 130°C.

[0142] Similar to Example 6, the height of the raised portion (rim) was obtained, and "Tension in Radial Direction," "Wrinkle," and
15 "Floating (Separation) after 48 hours" were evaluated.

Example 8

[0143] A raised portion (rim) was formed by attaching the same film as that of Example 2 to the sapphire wafer (mount process) and
20 performing thermocompression bonding (press process). Specifically, the semiconductor wafer surface protection film was cut in a size larger than that of the sapphire wafer. In addition, the sapphire wafer having a thickness of 650 μm and a size of 4 inches was prepared. The sapphire wafer was disposed on the semiconductor wafer surface
25 protection film as illustrated in Fig. 2A. The hot plate was heated to 25°C, and the semiconductor wafer surface protection film was

compressively bonded to the sapphire wafer using a roller, so that a laminate including the sapphire wafer and the semiconductor wafer surface protection film was obtained. The roller pressure was set to 0.5 MPa, and the roller speed was set to 10 mm/sec.

5 [0144] Then, as illustrated in Fig. 2C, the obtained laminate was interposed between the upper heating plate (heating plate disposed in the semiconductor wafer surface protection film) and the lower heating plate (heating plate disposed in the sapphire wafer side) of the hot press machine, and compressive bonding was performed with a pressure
10 of 10 MPa for 180 seconds. In this case, the temperature of the upper heating plate was set to 140°C, and the temperature of the lower heating plate was set to 120°C, so that average temperature TP thereof was set to 130°C.

[0145] Similar to Example 6, the height of the raised portion (rim)
15 was obtained, and "Tension in Radial Direction," "Wrinkle," and "Floating (Separation) after 48 hours" were evaluated.

Comparative Example 5

[0146] A raised portion (rim) was formed by attaching the same film
20 as that of Example 2 to the sapphire wafer (mount process) and performing thermocompression bonding (press process). Specifically, the semiconductor wafer surface protection film was cut in a size larger than that of the sapphire wafer. In addition, the sapphire wafer having a thickness of 650 μm and a size of 4 inches was prepared. The
25 sapphire wafer was disposed on the semiconductor wafer surface protection film as illustrated in Fig. 2A. The hot plate was heated to

100°C, and the semiconductor wafer surface protection film was compressively bonded to the sapphire wafer using a roller, so that a laminate including the sapphire wafer and the semiconductor wafer surface protection film was obtained. The roller pressure was set to
5 0.5 MPa, and the roller speed was set to 10 mm/sec.

[0147] Then, as illustrated in Fig. 2C, the obtained laminate was interposed between the upper heating plate (heating plate disposed in the semiconductor wafer surface protection film) and the lower heating plate (heating plate disposed in the sapphire wafer side) of the hot
10 press machine, and compressive bonding was performed with a pressure of 10 MPa for 180 seconds. In this case, the temperature of the upper heating plate was set to 110°C, and the temperature of the lower heating plate was set to 90°C, so that average temperature TP thereof was set to 100°C.

15 [0148] Similar to Example 6, the height of the raised portion (rim) was obtained, and "Tension in Radial Direction," "Wrinkle," and "Floating (Separation) after 48 hours" were evaluated.

Table 4

			Example 6	Example 7	Example 8	Comparative Example 5
Base layer (A)	Material		hPP	hPP	hPP	hPP
	Storage elastic modulus G_A (Pa)	40°C	2.4E+08	2.4E+08	2.4E+08	2.4E+08
		100°C	5.6E+07	5.6E+07	5.6E+07	5.6E+07
		150°C	4.7E+06	4.7E+06	4.7E+06	4.7E+06
	Density (kg/m ³)		910	910	910	910
	MFR (g/10min)		7	7	7	7
	Thickness (μm)		30	30	30	30
Softening layer (B)	Material		LLDPE	LLDPE	LLDPE	LLDPE
	Storage elastic modulus G_B (Pa)	40°C	9.3E+07	9.3E+07	9.3E+07	9.3E+07
		100°C	8.4E+06	8.4E+06	8.4E+06	8.4E+06
		150°C	6.2E+03	6.2E+03	6.2E+03	6.2E+03
	Density (kg/m ³)		918	918	918	918
	MFR (g/10min)		3.8	3.8	3.8	3.8
	Thickness (μm)		30	30	30	30
Adhesive layer (C)	Material		UV-curable adhesive	UV-curable adhesive	UV-curable adhesive	UV-curable adhesive
	Storage elastic modulus G_C (Pa)	25°C	9.0E+04	9.0E+04	9.0E+04	9.0E+04
	Peel strength (N/25mm)		3	3	3	3
	Thickness (μm)		5	5	5	5
	Total thickness (μm)		65	65	65	65
Mount process	Hot plate temperature T_M (°C)		140	100	25	100
	Roller pressure (MPa)		0.5	0.5	0.5	0.5
	Roller speed (mm/sec)		10	10	10	10
Press process	Upper heating plate temperature $TP1$ (°C)		140	140	140	110
	Lower heating plate temperature $TP2$ (°C)		120	120	120	90
	Thermocompression bonding temperature TP (°C)		130	130	130	100
	Pressure (MPa)		10	10	10	10
	Time (second)		180	180	180	180
Tension in radial direction	allowable tension (o); unallowable tension (x)		o	o	x	o
Rim	Height (μm)		250	250	250	50
Wrinkle	unallowable wrinkles (x); allowable wrinkles (o)		o	x	x	o
Separation after 48 hrs.	unallowable separation (x); allowable separation (o)		o	o	x	o

[0149] In Example 6, temperature TM in the mount process was higher than temperature TP of the press process, and temperature TP was higher than softening temperature TmB of softening layer (B) by 14°C. For this reason, a rim having a sufficient height was formed, and there were no wrinkle and no separation between the sapphire wafer and the protection film.

[0150] In Example 7, temperature TM of the mount process is lower than temperature TP of the press process by 30°C. For this reason, while it was possible to form a rim having a sufficient height, generation of wrinkles was recognized. Further, in Example 8, temperature TM of the mount process is lower than temperature TP of the press process by 105°C. For this reason, while it was possible to form a rim having a sufficient height, generation of wrinkles was recognized, and a separation between the sapphire wafer and the protection film was also recognized.

[0151] In Comparative Example 5, temperature TP of the press process is lower than softening temperature TmB of softening layer (B). For this reason, it was difficult to form a rim having a sufficient height.

Example 9

[0152] A raised portion (rim) was formed by attaching the same film as that of Example 2 to the sapphire wafer (mount process) and performing thermocompression bonding (press process). Specifically, the semiconductor wafer surface protection film was cut in a size larger than that of the sapphire wafer. In addition, the sapphire wafer having a thickness of 650 μm and a size of 4 inches was prepared. The

sapphire wafer was disposed on the semiconductor wafer surface protection film as illustrated in Fig. 2A. The hot plate was heated to 140°C, and the semiconductor wafer surface protection film was compressively bonded to the sapphire wafer using a roller, so that a
5 laminate including the sapphire wafer and the semiconductor wafer surface protection film was obtained. The roller pressure was set to 0.5 MPa, and the roller speed was set to 10 mm/sec.

[0153] Then, as illustrated in Fig. 2C, the obtained laminate was interposed between the upper heating plate (heating plate disposed in
10 the semiconductor wafer surface protection film) and the lower heating plate (heating plate disposed in the sapphire wafer side) of the hot press machine, and compressive bonding was performed with a pressure of 10 MPa for 180 seconds. In this case, the temperature of the upper heating plate was set to 140°C, and the temperature of the lower heating
15 plate was set to 100°C, so that average temperature TP thereof was set to 120°C.

[0154] Then, similar to Example 6, the height of the raised portion (rim) was measured.

20 Example 10

[0155] A raised portion (rim) was formed by attaching the same film as that of Example 2 to the sapphire wafer (mount process) and performing thermocompression bonding (press process). Specifically, the semiconductor wafer surface protection film was cut in a size larger
25 than that of the sapphire wafer. In addition, the sapphire wafer having a thickness of 650 μm and a size of 4 inches was prepared. The

sapphire wafer was disposed on the semiconductor wafer surface protection film as illustrated in Fig. 2A. The hot plate was heated to 140°C, and the semiconductor wafer surface protection film was compressively bonded to the sapphire wafer using a roller, so that a
5 laminate including the sapphire wafer and the semiconductor wafer surface protection film was obtained. The roller pressure was set to 0.5 MPa, and the roller speed was set to 10 mm/sec.

[0156] As illustrated in Fig. 2C, the obtained laminate was then interposed between the upper heating plate (heating plate disposed in
10 the semiconductor wafer surface protection film) and the lower heating plate (heating plate disposed in the sapphire wafer side) of the hot press machine, and compressive bonding was performed with a pressure of 10 MPa for 180 seconds. In this case, the temperature of the upper heating plate was set to 140°C, and the temperature of the lower heating
15 plate was set to 140°C, so that average temperature TP thereof was set to 140°C.

[0157] Then, similar to Example 6, the height of the raised portion (rim) was measured.

Table 5

			Example 9	Example 10
Base layer (A)	Material		hPP	hPP
	Storage elastic modulus G_A (Pa)	40°C	2.4E+08	2.4E+08
		100°C	5.6E+07	5.6E+07
		150°C	4.7E+06	4.7E+06
	Density (kg/m ³)		910	910
	MFR (g/10min)		7	7
	Thickness (μm)		30	30
Softening layer (B)	Material		LLDPE	LLDPE
	Storage elastic modulus G_B (Pa)	40°C	9.3E+07	9.3E+07
		100°C	8.4E+06	8.4E+06
		150°C	6.2E+03	6.2E+03
	Density (kg/m ³)		918	918
	MFR (g/10min)		3.8	3.8
	Thickness (μm)		30	30
Adhesive layer (C)	Material		UV-curable adhesive	UV-curable adhesive
	Storage elastic modulus G_C (Pa)	25°C	9.0E+04	9.0E+04
	Peel strength (N/25mm)		3	3
	Thickness (μm)		5	5
	Total thickness (μm)		65	65
Mount process	Temperature of hot plate TM (°C)		140	140
	Roller pressure (MPa)		0.5	0.5
	Roller speed (mm/sec)		10	10
Press process	Temperature of upper heating plate TP1 (°C)		140	140
	Temperature of lower heating plate TP2 (°C)		100	140
	Thermocompression bonding temperature TP (°C)		120	140
	Pressure (MPa)		10	10
	Time (sec)		180	180
Rim	Height (μm)		270	170

[0158] In Example 9, temperature TM of the mount process is higher than temperature TP of the press process, and temperature TP is higher than softening temperature TmB of softening layer (B) by 4°C. In addition, temperature TP1 of the upper heating plate in the press process is higher than temperature TP2 of the lower heating plate. For

this reason, a rim having a sufficient height was formed.

[0159] Meanwhile, in Example 10, temperature TM of the mount process is equal to temperature TP of the press process. In addition, temperature TP1 of the upper heating plate in the press process is equal to temperature TP2 of the lower heating plate. For this reason, the rim was slightly flattened, and the height of the rim decreases compared to Example 7.

Examples 11 to 14

[0160] A raised portion (rim) was formed by attaching the same film as that of Example 2 to the sapphire wafer (mount process) and performing thermocompression bonding (press process). Specifically, the semiconductor wafer surface protection film was cut in a size larger than that of the sapphire wafer. In addition, the sapphire wafer having a thickness of 650 μm and a size of 4 inches was prepared. The sapphire wafer was disposed on the semiconductor wafer surface protection film as illustrated in Fig. 2A. The hot plate was heated to 140°C, and the semiconductor wafer surface protection film was compressively bonded to the sapphire wafer using a roller, so that a laminate including the sapphire wafer and the semiconductor wafer surface protection film was obtained. The roller pressure was set to 0.5 MPa, and the roller speed was set to 10 mm/sec.

[0161] Then, as illustrated in Fig. 7A, the obtained laminate was interposed between the upper heating plate (heating plate disposed in the semiconductor wafer surface protection film) and the lower heating plate (heating plate disposed in the sapphire wafer side) having a

conical protrusion as illustrated in Fig. 7B of the hot press machine, and compressive bonding was performed with a pressure of 10 MPa for 180 seconds. In this case, the temperature of the upper heating plate was set to 140°C, and the temperature of the lower heating plate was set to 120°C. In Example 11, the height of the protrusion was set to 0 μm (no protrusion). In Example 12, the height of the protrusion was set to 5 μm . In Example 13, the height of the protrusion was set to 15 μm . In Example 14, the height of the protrusion was set to 25 μm . In each of Examples 11 to 14, a thickness difference (difference between the maximum thickness and the minimum thickness) of the semiconductor wafer surface protection film subjected to the press process was measured, and the height of the raised portion (rim) was measured as in Example 6.

Table 6

	Height of conical protrusion (μm)	Thickness difference (μm)	Height of rim (μm)
Example 11	0	15	>200
Example 12	5	13	>200
Example 13	15	4	>200
Example 14	25	7	about 200

[0162] As shown in Table 6, by providing a protrusion in the lower heating plate, it is possible to limit a thickness difference of the semiconductor wafer surface protection film subjected to the press process and also form the raised portion (rim).

Industrial Applicability

[0163] The semiconductor wafer surface protection film according to

the present invention allows for rear surface grinding without causing damages even to hard, fragile semiconductor wafers such as sapphire wafers.

5 Reference Signs List

[0164]

1 SAPPHIRE SUBSTRATE

2 WAX RESIN LAYER

3 ABRASIVE MATERIAL

10 4 CONVENTIONAL SEMICONDUCTOR WAFER PROTECTION FILM

10 SEMICONDUCTOR WAFER SURFACE PROTECTION FILM

12 BASE LAYER (A)

14 SOFTENING LAYER (B)

16 ADHESIVE LAYER (C)

15 18 LESS ADHESIVE LAYER (D)

20 SEMICONDUCTOR WAFER

20A PATTERNED SURFACE OF SEMICONDUCTOR WAFER

20B NON-PATTERNED SURFACE (REAR SURFACE) OF
SEMICONDUCTOR WAFER

20 22-1 UPPER HEATING PLATE

22-2 LOWER HEATING PLATE

24 RAISED PORTION (RIM)

26 CHUCK TABLE

28 ABRASIVE MATERIAL

CLAIMS

Claim 1 A semiconductor wafer surface protection film comprising:

base layer (A) having a storage elastic modulus at 150°C
5 (G_A(150)) of equal to or higher than 1 MPa; and

softening layer (B) having a storage elastic modulus at a temperature selected from 120 to 180°C (G_B(120 to 180)) of equal to or lower than 0.05 MPa and a storage elastic modulus at 40°C (G_B(40)) of equal to or higher than 10 MPa .

10

Claim 2 The semiconductor wafer surface protection film according to claim 1, wherein a storage elastic modulus at 100°C (G_B(100)) of the softening layer (B) is equal to or higher than 1 MPa.

15 Claim 3 The semiconductor wafer surface protection film according to claim 1, wherein a tensile elastic modulus at 60°C E_B(60) of the softening layer (B) and a tensile elastic modulus at 25°C (E_B(25)) of the softening layer (B) satisfy the relationship $1 > E_B(60)/E_B(25) > 0.1$.

20

Claim 4 The semiconductor wafer surface protection film according to claim 1, further comprising adhesive layer (C) disposed opposite to the base layer (A) across the softening layer (B),

wherein an adhesive force of the adhesive layer (C) measured in
25 accordance with JIS-Z0237 is 0.1 to 10 N/25 mm.

Claim 5 The semiconductor wafer surface protection film according to claim 1, wherein the base layer (A) is an outermost layer of the semiconductor wafer surface protection film.

5 Claim 6 The semiconductor wafer surface protection film according to claim 4, wherein the adhesive layer (C) is an outermost layer positioned opposite to the base layer (A) across the softening layer (B).

10 Claim 7 The semiconductor wafer surface protection film according to claim 1, wherein the softening layer (B) includes a homopolymer of a hydrocarbon olefin, a copolymer of a hydrocarbon olefin, or a mixture thereof.

15 Claim 8 The semiconductor wafer surface protection film according to claim 1, wherein a resin constituting the softening layer (B) has a density of 880 to 960 kg/m³.

Claim 9 The semiconductor wafer surface protection film
20 according to claim 1, wherein the base layer (A) is a polyolefin layer, a polyester layer, or a laminate of the polyolefin layer and the polyester layer.

Claim 10 A method of manufacturing a semiconductor device,
25 comprising:

 disposing a semiconductor wafer on a semiconductor wafer

surface protection film such that a patterned surface of the semiconductor wafer contacts the semiconductor wafer surface protection film;

forming around a circumference of the semiconductor wafer a raised portion of the semiconductor wafer surface protection film for holding the semiconductor wafer;

grinding a non-patterned surface of the semiconductor wafer held by the raised portion; and

separating the semiconductor wafer surface protection film from the patterned surface of the semiconductor wafer,

wherein a storage elastic modulus at 100°C (G(100)) of the raised portion is equal to or higher than 1 MPa.

Claim 11 The method according to claim 10, wherein the semiconductor wafer surface protection film is the semiconductor wafer surface protection film according to claim 1, and

the raised portion is formed by performing thermocompression bonding for the semiconductor wafer surface protection film and the semiconductor wafer under a pressure of 1 to 10 MPa at 120 to 180°C.

20

Claim 12 The method according to claim 11, wherein temperature T_M of the film in the step of disposing the semiconductor wafer on the semiconductor wafer surface protection film such that the patterned surface of the semiconductor wafer contacts the semiconductor wafer surface protection film, a thermocompression bonding temperature T_P in the step of forming the raised portion of the semiconductor wafer

surface protection film, and softening temperature T_{mB} of the softening layer (B) satisfy relationships represented by the following equations:

[1]

5 $TP \leq TM \quad \dots(\text{Equation 1})$

[2]

$T_{mB} < TP < T_{mB} + 40^{\circ}\text{C} \quad \dots(\text{Equation 2})$

Claim 13 The method according to claim 11, wherein the
10 semiconductor wafer is disposed on the semiconductor wafer surface protection film such that the softening layer (B) of the semiconductor wafer surface protection film is disposed on the patterned surface side of the semiconductor wafer relative to the base layer (A).

15 Claim 14 The method according to claim 10, wherein the semiconductor wafer includes a high-hardness substrate having a Mohs' hardness of 8 or higher.

Claim 15 A semiconductor wafer press apparatus that presses a
20 mount frame that includes a semiconductor wafer, ring frame A having a rim surrounding the semiconductor wafer, and the semiconductor wafer surface protection film according to claim 1 attached over a patterned surface of the semiconductor wafer and the frame A, with the mount frame being interposed between an upper press plate having a
25 heating mechanism and a lower press plate opposite to the upper press plate,

wherein outer diameter DW of the semiconductor wafer and inner diameter DA_{IN} of ring frame A satisfy the relationship Equation (1): $DW < DA_{IN}$,

the lower press plate has a protrusion on a surface opposite to the upper press plate, and

a circumference of a surface of the protrusion that makes contact with the mount frame at the time of pressing has a circular shape.

Claim 16 The semiconductor wafer press apparatus according to claim 15, wherein the protrusion has a height of 1 to 100 μm .

Claim 17 The semiconductor wafer press apparatus according to claim 15, wherein a height of the protrusion is within 15 to 100% of a thickness of the softening layer (B) of the semiconductor wafer surface protection film.

Claim 18 The semiconductor wafer press apparatus according to claim 15, wherein diameter CD of the protrusion satisfies the relationship $DW < CD < DA_{IN}$.

Claim 19 A semiconductor wafer mount apparatus for manufacturing a mount frame including a semiconductor wafer, ring-like supporting member B surrounding the semiconductor wafer, ring frame A surrounding the semiconductor wafer and ring-like supporting member B, and the semiconductor wafer surface protection

film according to claim 1 attached over a patterned surface of the semiconductor wafer, ring-like supporting member B, and ring frame A,

wherein outer diameter DW of the semiconductor wafer, an inner diameter DA_{IN} of ring frame A, ring outer diameter DB_{OUT} of ring-like supporting member B, and ring inner diameter DB_{IN} of ring-like supporting member B satisfy the relationship Equation (1): DW < DB_{IN} < DB_{OUT} < DA_{IN}, and

the semiconductor wafer mount apparatus comprises:

a heating unit that heats a surface opposite to a patterned surface of the semiconductor wafer;

an attaching roller that rolls over a patterned surface of the semiconductor wafer, ring frame A, and ring-like supporting member B to attach the semiconductor wafer surface protection film; and

a tape cutting mechanism that cuts the surface protection film along an exterior shape of ring frame A.

Claim 20 The semiconductor wafer mount apparatus according to claim 19, wherein both differences ΔD1 and ΔD2 expressed as the following equations are within 1% of outer diameter DW of the semiconductor wafer:

$$\Delta D1 = DB_{IN} - DW; \dots (2)$$

$$\Delta D2 = DA_{IN} - DB_{OUT} \dots (3)$$