

[DESCRIPTION]

[TITLE OF INVENTION]

METHOD OF MANUFACTURING THIRD LAMINATE, METHOD OF MANUFACTURING FOURTH LAMINATE, METHOD OF MANUFACTURING SEMICONDUCTOR DEVICE WITH BACK SURFACE PROTECTIVE FILM, AND THIRD LAMINATE

[Technical Field]

[0001]

The present invention relates to a method of manufacturing a third laminate, a method of manufacturing a fourth laminate, a method of manufacturing a semiconductor device with a back surface protective film, and a third laminate. Specifically, the present invention relates to a method of manufacturing a third laminate including a workpiece, such as a semiconductor wafer; a film for forming a back surface protective film; and a support sheet laminated in this order; a method of manufacturing a fourth laminate including a workpiece, such as a semiconductor wafer; a back surface protective film; and a support sheet laminated in this order; and a method of manufacturing a semiconductor device with a back surface protective film using these; and a third laminate including a workpiece, such as a semiconductor wafer; a film for forming a back surface protective film; and a support sheet laminated in this order.

This application claims priority to JP 2019-086298 filed in Japan on April 26, 2019, the contents of which are incorporated herein.

[Background Art]

[0002]

In recent years, semiconductor devices have been manufactured by employing a mounting method, called “face down method”. In the face down method, a

semiconductor chip having an electrode, such as a bump, on a circuit surface is used, and the electrode is bonded to a substrate. Consequently, there may be a case where the back surface of the semiconductor chip opposite to the circuit surface is exposed.

[0003]

On the exposed back surface of the semiconductor chip, a resin film containing an organic material may be formed as a back surface protective film, and the semiconductor chip with a back surface protective film may be incorporated in a semiconductor device. The back surface protective film is utilized to prevent the occurrence of a crack in the semiconductor chip after dicing or packaging (e.g., Patent Documents 1 and 2).

[0004]

Such a semiconductor chip with a back surface protective film is manufactured, for example, through processes illustrated in Fig. 9. That is, this method known in the art involves laminating a film 13 for forming a back surface protective film on a back surface 8b of a semiconductor wafer 8 having a circuit surface (Fig. 9(A)); thermally curing or curing with an energy ray the film 13 for forming a back surface protective film to form a back surface protective film 13' (Fig. 9(B)); creating a laser marking on the back surface protective film 13' (Fig. 9(C)); laminating a support sheet 10 on the back surface protective film 13' (Fig. 9(D)); dicing the semiconductor wafer 8 and the back surface protective film 13' to form a semiconductor chip 7 with a back surface protective film (Fig. 9(E) and Fig. 9(F)); and picking up the semiconductor chip 7 with a back surface protective film from the support sheet 10. Any order of the curing and the creating the laser marking may be employed; after laminating the film 13 for forming a back surface protective film on the back surface 8b of the semiconductor wafer 8 having a circuit surface (Fig. 9(A)) and creating the laser marking on the film 13 for forming a

back surface protective film, the film 13 for forming a back surface protective film is thermally cured or cured with an energy ray to form the back surface protective film 13', which may be followed by the processes of Fig. 9(D) to Fig. 9(G). Here, an apparatus for laminating the film 13 for forming a back surface protective film on the back surface 8b of the semiconductor wafer 8 in Fig. 9(A) and an apparatus for laminating the support sheet 10 on the back surface protective film 13' in Fig. 9(D) are separate apparatuses. These methods are utilized not only for manufacturing a semiconductor device that is a semiconductor chip formed by dicing a semiconductor wafer into individual pieces but also for manufacturing a semiconductor device having at least one electronic component sealed with a sealing resin from a semiconductor device panel composed of an assembly of semiconductor devices having at least one electronic component sealed with a sealing resin by dicing the semiconductor device panel in the same manner.

[0005]

In addition, a composite sheet for forming a protective film in which the film 13 for forming a back surface protective film and the support sheet 10 are integrated is used for manufacturing a semiconductor chip with a back surface protective film (e.g., Patent Document 2).

[0006]

A method of manufacturing a semiconductor chip with a back surface protective film using a composite sheet for forming a protective film undergoes, for example, processes illustrated in Fig. 10. That is, this method known in the art involves attaching a film 13 for forming a back surface protective film of a composite sheet 1 for forming a protective film to a back surface 8b of a semiconductor wafer 8 having a circuit surface, the composite sheet 1 for forming a protective film being formed by laminating the film 13 for forming a back surface protective film and the support sheet 10, (Fig. 10(A'));

peeling off a tape 17 for protecting a circuit surface (Fig. 10(B')); thermally curing or curing with an energy ray the film 13 for forming a back surface protective film to form a back surface protective film 13' (Fig. 10(C')); creating a laser marking on the back surface protective film 13' from the side of the support sheet 10 (Fig. 10(D')); dicing the semiconductor wafer 8 and the back surface protective film 13' to form a semiconductor chip 7 with a back surface protective film (Fig. 10(E') and Fig. 10(F')); and picking up the semiconductor chip 7 with a back surface protective film from the support sheet 10. Also in this case, any order of the curing and the creating the laser marking may be employed. These methods are also utilized not only for manufacturing a semiconductor device that is a semiconductor chip but also for manufacturing a semiconductor device having at least one electronic component sealed with a sealing resin from a semiconductor device panel composed of an assembly of semiconductor devices having at least one electronic component sealed with a sealing resin by dicing the semiconductor device panel in the same manner.

[Citation List]

[Patent Literature]

[0007]

Patent Document 1: JP 4271597 B

Patent Document 2: JP 5363662 B

[Summary of Invention]

[Technical Problem]

[0008]

In the method of manufacturing a semiconductor device illustrated in Fig. 9, in which the film 13 for forming a back surface protective film is laminated on the back surface 8b of the semiconductor wafer 8, the exposed film 13 for forming a back surface

protective film or back surface protective film 13' can be directly subjected to laser marking. However, in the method of manufacturing a semiconductor device illustrated in Fig. 10, in which the film 13 for forming a back surface protective film of the composite sheet 1 for forming a protective film is attached to the back surface 8b of the semiconductor wafer 8, creating the laser marking is performed by irradiation with laser light from the side of the support sheet 10 through the support sheet 10, but this results in a blurred outline of a letter or symbol marked at the interface between the film 13 for forming a back surface protective film and the support sheet 10, impairing the visibility after marking.

[0009]

Thus, an object of the present invention is to provide a method of manufacturing a third laminate including a workpiece, such as a semiconductor wafer; a film for forming a back surface protective film; and a support sheet laminated in this order, and the method enables creation of a laser marking on the back surface protective film through the support sheet and provides good visibility of the laser marking. In addition, an object of the present invention is to provide a method of manufacturing a fourth laminate including a workpiece, such as a semiconductor wafer; a back surface protective film; and a support sheet laminated in this order, and the method enables creation of a laser marking on the back surface protective film through the support sheet and provides good visibility of the laser marking. Furthermore, an object of the present invention is to provide a method of manufacturing a semiconductor device with a back surface protective film using these.

[Solution to Problem]

[0010]

The present invention provides a method of manufacturing a third laminate, a

method of manufacturing a fourth laminate, a method of manufacturing a semiconductor device with a back surface protective film, and a third laminate described below.

[0011]

(1) A method of manufacturing a third laminate including a workpiece, a film for forming a back surface protective film, and a support sheet laminated in this order, wherein

one surface of the workpiece is a circuit surface, and another surface of the workpiece is a back surface;

one surface of the film for forming a back surface protective film is a smooth surface, and another surface of the film for forming a back surface protective film is a rough surface rougher than the smooth surface; and

the method includes, performed in this order,

(i) attaching the rough surface of the film for forming a back surface protective film, face-to-face, to the back surface of the workpiece (first lamination); and

(ii) attaching the support sheet to the smooth surface of the film for forming a back surface protective film (second lamination).

[0012]

(2) The method of manufacturing a third laminate according to (1) described above, wherein at least a process from the first lamination to the second lamination is performed with an apparatus for attaching the film for forming a back surface protective film and an apparatus for attaching the support sheet being connected to each other or performed in the same apparatus.

(3) The method of manufacturing a third laminate according to (1) or (2) described above, wherein a second laminate including the film for forming a back surface protective film attached to the workpiece is transferred one by one from the first

lamination to the second lamination.

(4) The method of manufacturing a third laminate according to any one of (1) to (3) described above, wherein a transfer distance of the workpiece from an attaching starting point of the first lamination to an attaching completion point of the second lamination is 7000 mm or shorter.

(5) The method of manufacturing a third laminate according to any one of (1) to (4) described above, wherein a transfer time of the workpiece from an attaching starting time of the first lamination to an attaching completion time of the second lamination is 150 s or shorter.

[0013]

(6) The method of manufacturing a third laminate according to any one of (1) to (5) described above, wherein

the circuit surface of the workpiece is protected with a tape for protecting a circuit surface; and

the method includes peeling off the tape for protecting a circuit surface from the circuit surface of the workpiece after the second lamination.

(7) The method of manufacturing a third laminate according to (6) described above, wherein the back surface of the workpiece is a ground surface, and the tape for protecting a circuit surface is a tape for grinding a back surface.

(8) The method of manufacturing a third laminate according to any one of (1) to (7) described above, wherein the workpiece is a semiconductor wafer.

(9) The method of manufacturing a third laminate according to any one of (1) to (7) described above, wherein the workpiece is a semiconductor device panel composed of an assembly of semiconductor devices in which at least one electronic component is sealed with a sealing resin.

[0014]

(10) The method of manufacturing a third laminate according to any one of (1) to (9) described above, wherein

the support sheet is provided with a pressure sensitive adhesive layer on a substrate; and

the method further includes attaching the pressure sensitive adhesive layer of the support sheet to the smooth surface of the film for forming a back surface protective film (second lamination).

(11) The method of manufacturing a third laminate according to (10) described above, wherein the pressure sensitive adhesive layer is energy ray-curable.

[0015]

(12) The method of manufacturing a third laminate according to any one of (1) to (11) described above, the method including creating a laser marking on the film for forming a back surface protective film by irradiating the film for forming a back surface protective film with a laser from the side of the support sheet.

(13) A method of manufacturing a fourth laminate including a workpiece, a back surface protective film, and a support sheet laminated in this order, the method including:

forming the back surface protective film by curing the film for forming a back surface protective film of the third laminate manufactured by the manufacturing method described in any one of (1) to (12) described above.

(14) The method of manufacturing a fourth laminate according to (13) described above, the method including creating a laser marking on the back surface protective film by irradiating the back surface protective film with a laser from the side of the support sheet.

[0016]

(15) A method of manufacturing a semiconductor device with a back surface protective film, the method including:

dicing the workpiece and the back surface protective film of the fourth laminate manufactured by the manufacturing method described in (13) or (14) described above to form a semiconductor device with a back surface protective film; and

picking up the semiconductor device with a back surface protective film from the support sheet.

(16) A method of manufacturing a semiconductor device with a back surface protective film, the method including:

dicing the film for forming a back surface protective film and the workpiece of the third laminate manufactured by the manufacturing method described in any one of (1) to (12) described above to form a semiconductor device with a film for forming a back surface protective film;

forming a back surface protective film by curing the film for forming a back surface protective film; and

picking up the semiconductor device with a film for forming a back surface protective film or a semiconductor device with a back surface protective film from the support sheet.

(17) The method of manufacturing a semiconductor device with a back surface protective film according to (15) or (16) described above, wherein the film for forming a back surface protective film is thermosetting; and the forming a back surface protective film includes thermally treating the film for forming a back surface protective film to thermally cure the film for forming a back surface protective film.

(18) The method of manufacturing a semiconductor device with a back surface protective film according to (15) or (16) described above, wherein the film for forming a

back surface protective film is energy ray-curable; and the forming a back surface protective film includes irradiating the film for forming a back surface protective film with an energy ray to cure the film for forming a back surface protective film with an energy ray.

[0017]

(19) A third laminate including a workpiece, a film for forming a back surface protective film, and a support sheet laminated in this order, wherein

one surface of the workpiece is a circuit surface, and another surface of the workpiece is a back surface;

one surface of the film for forming a back surface protective film is a smooth surface, and another surface of the film for forming a back surface protective film is a rough surface rougher than the smooth surface;

the rough surface of the film for forming a back surface protective film is bonded to the back surface of the workpiece; and

the support sheet is bonded to the smooth surface of the film for forming a back surface protective film.

[Advantageous Effects of Invention]

[0018]

The present invention provides a method of manufacturing a third laminate including a workpiece, a film for forming a back surface protective film, and a support sheet laminated in this order, and the method enables creation of a laser marking on the back surface protective film through the support sheet and provides good visibility of the laser marking. In addition, the present invention provides a method of manufacturing a fourth laminate including a workpiece, a back surface protective film, and a support sheet laminated in this order, and the method enables creation of a laser marking on the back

surface protective film through the support sheet and provides good visibility of the laser marking. Furthermore, the present invention provides a method of manufacturing a semiconductor device with a back surface protective film using these.

[Brief Description of Drawings]

[0019]

Fig. 1 is a schematic cross-sectional view schematically illustrating an example of an embodiment of a method of manufacturing a third laminate.

Fig. 2 is a schematic cross-sectional view illustrating an example of a film for forming a back surface protective film.

Fig. 3 is a schematic cross-sectional view schematically illustrating another example of an embodiment of the method of manufacturing a third laminate.

Fig. 4 is a schematic cross-sectional view schematically illustrating an example of an embodiment of a method of manufacturing a fourth laminate.

Fig. 5 is a schematic cross-sectional view schematically illustrating another example of an embodiment of the method of manufacturing a fourth laminate.

Fig. 6 is a schematic cross-sectional view schematically illustrating an example of an embodiment of a method of manufacturing a semiconductor device with a back surface protective film.

Fig. 7 is a schematic cross-sectional view schematically illustrating another example of an embodiment of the method of manufacturing a semiconductor device with a back surface protective film.

Fig. 8 is a schematic cross-sectional view schematically illustrating another example of an embodiment of the method of manufacturing a semiconductor device with a back surface protective film.

Fig. 9 is a schematic cross-sectional view schematically illustrating an example

of a method of manufacturing a semiconductor chip with a back surface protective film known in the art.

Fig. 10 is a schematic cross-sectional view schematically illustrating another example of a method of manufacturing a semiconductor chip with a back surface protective film known in the art.

Fig. 11 is a schematic cross-sectional view illustrating an example of a support sheet 10 provided with a pressure sensitive adhesive layer 12 on a substrate 11.

[Description of Embodiments]

[0020]

A method of manufacturing a third laminate, a method of manufacturing a fourth laminate, and a method of manufacturing a semiconductor device, which are embodiments to which the present invention is applied, will be described in detail below. In the drawings used in the following descriptions, to clarify features, characteristic portions may be enlarged for convenience, and a size ratio or the like of each component is not necessarily the same as that of an actual embodiment.

[0021]

(Method of manufacturing third laminate)

Fig. 1 is a schematic cross-sectional view schematically illustrating an example of an embodiment of a method of manufacturing a third laminate. A method of manufacturing a third laminate according to the present embodiment is a method of manufacturing a third laminate 19 including a workpiece 14, a film 13 for forming a back surface protective film, and a support sheet 10 laminated in this order, in which

one surface of the workpiece 14 is a circuit surface 14a, and another surface of the workpiece 14 is a back surface 14b (Fig. 1(a));

one surface of the film 13 for forming a back surface protective film is a smooth

surface 13b, and another surface of the film 13 for forming a back surface protective film is a rough surface 13a rougher than the smooth surface 13b; and

the method (Fig. 1(a) to Fig. 1(e)) includes, performed in this order,

(i) attaching the rough surface 13a of the film 13 for forming a back surface protective film, face-to-face, to the back surface 14b of the workpiece 14 (first lamination); and

(ii) attaching the support sheet 10 to the smooth surface 13b of the film 13 for forming a back surface protective film (second lamination).

[0022]

That is, the third laminate according to the present embodiment is a third laminate including the workpiece 14, the film 13 for forming a back surface protective film, and the support sheet 10 laminated in this order, in which

one surface of the workpiece 14 is the circuit surface 14a, and another surface of the workpiece 14 is the back surface 14b;

one surface of the film 13 for forming a back surface protective film is the smooth surface 13b, and another surface of the film 13 for forming a back surface protective film is the rough surface 13a rougher than the smooth surface 13b; and

the rough surface 13a of the film 13 for forming a back surface protective film is bonded to the back surface 14b of the workpiece 14; and

the support sheet 10 is bonded to the smooth surface 13b of the film 13 for forming a back surface protective film (Fig. 1(e)).

[0023]

In the present embodiment, a semiconductor wafer is used as the workpiece 14 illustrated in Fig. 1(a). One surface of the semiconductor wafer is the circuit surface 14a, on which bumps are formed. In addition, the circuit surface 14a and the bumps of the

semiconductor wafer are protected with a tape 17 for protecting a circuit surface to prevent collapse of the circuit surface 14a and the bumps of the semiconductor wafer during grinding of the back surface of the semiconductor wafer and occurrence of a dimple or a crack on the wafer back surface. The tape 17 for protecting a circuit surface is a tape for grinding a back surface, and the back surface of the semiconductor wafer used as the workpiece 14 (i.e., the back surface 14b of the workpiece) is a ground surface.

[0024]

The workpiece 14 is not limited as long as the workpiece has a circuit surface 14a on one side and has another surface that can be referred to as a back surface. The workpiece 14 can be exemplified by semiconductor wafers having a circuit surface on one side; and semiconductor device panels composed of an assembly of semiconductor devices with a terminal, in which individual electronic components in a form of individual pieces are sealed with a sealing resin and the assembly has a terminal-forming surface (in other words, a circuit surface) of the semiconductor device with a terminal on one side.

[0025]

For the tape 17 for protecting a circuit surface, a surface protective sheet disclosed, for example, in JP 2016-192488 A or JP 2009-141265 A can be used. The tape 17 for protecting a circuit surface is provided with a pressure sensitive adhesive layer having moderate removability. The pressure sensitive adhesive layer may be formed from a pressure sensitive adhesive of a versatile weak pressure sensitive adhesive type, such as a rubber pressure sensitive adhesive, an acrylic pressure sensitive adhesive, a silicone pressure sensitive adhesive, a urethane pressure sensitive adhesive, or a vinyl ether pressure sensitive adhesive. In addition, the pressure sensitive adhesive layer may be an

energy ray-curable pressure sensitive adhesive that becomes removable when cured by irradiation with an energy ray. The tape 17 for protecting a circuit surface is in a form of a double sided tape, and the outer side of the tape 17 for protecting a circuit surface may be fixed to a rigid support, or the workpiece 14 may be fixed to a rigid support.

[0026]

In the present specification, the “energy ray” means electromagnetic waves or charged particle beams having energy quanta. Examples of the energy ray include ultraviolet light, radioactive rays, and electron beams. The ultraviolet light can be irradiated by using, for example, a high-pressure mercury lamp, a fusion lamp, a xenon lamp, black light, an LED lamp, or the like as an ultraviolet light source. The electron beam generated by an electron beam accelerator or the like can be irradiated.

In addition, in the present specification, “energy ray-curable” means a property of being cured by irradiation with an energy ray, and “non-energy ray-curable” refers to a property of being not cured by irradiation with an energy ray.

[0027]

In the first lamination according to the present embodiment illustrated in Fig. 1(b), the film 13 for forming a back surface protective film can be used as a first laminate 5 illustrated in Fig. 2. The first laminate 5 illustrated in Fig. 2 is provided with a first release film 151 on one surface (i.e., the rough surface 13a) of the film 13 for forming a back surface protective film and a second release film 152 on the other surface (i.e., the smooth surface 13b) opposite to the rough surface 13a. After peeling the first release film 151 on the side of the rough surface 13a, the rough surface 13a of the film 13 for forming a back surface protective film is laminated, face-to-face, on the back surface 14b of the workpiece 14 in the first lamination (Fig. 1(b)). The film 13 for forming a back surface protective film that may be used here is a film machined in advance to match the shape

of the workpiece 14 or a film machined in an apparatus immediately before use. Then, the second release film 152 on the side of the smooth surface 13b is preferably peeled off to form a second laminate 6 (Fig. 1(c)).

[0028]

For the film for forming a back surface protective film illustrated in Fig. 2, the film for forming a back surface protective film is formed, for example, by applying a protective film-forming composition containing a solvent onto the release surface of the second release film 152 having a thickness of 38 μm with a knife coater, and then drying at 120°C for 2 minutes in an oven. Then, the release surface of the first release film 151 having a thickness of 38 μm is overlaid on the film for forming a back surface protective film to bond both films together, and a film for forming a back surface protective film can be produced, the film for forming a back surface protective film including the first release film 151, the film for forming a back surface protective film (the film 13 for forming a back surface protective film in Fig. 2) (thickness: 25 μm), and the second release film 152. Such a film for forming a back surface protective film is suitably stored, for example, in a roll form. In addition, the release surface of the first release film 151 is formed into a rough surface with a surface roughness Ra of, for example, 200 nm, and the release surface of the second release film 152 is formed into a smooth surface with a surface roughness Ra of, for example, 30 nm, which is smoother than the surface roughness of the rough surface. This allows one surface of the film 13 for forming a back surface protective film to be the smooth surface 13b and the other surface opposite to the one surface of the film 13 for forming a back surface protective film to be the rough surface 13a, which is rougher than the smooth surface 13b. Then, after peeling off the first release film 151 on the side of the rough surface 13a, the rough surface 13a of the film 13 for forming a back surface protective film is attached, face-to-face, to the back

surface 14b of the workpiece 14 in the first lamination.

[0029]

Alternatively, even if the surface roughness Ra of the release surface of the first release film 151 and the surface roughness of the release surface of the second release film 152 are both smooth surfaces, one surface of the film 13 for forming a back surface protective film can be formed into the smooth surface 13b, and the other surface opposite to the one surface of the film 13 for forming a back surface protective film can be formed into a rough surface 13a, which is rougher than the smooth surface 13b, as follows.

[0030]

That is, a protective film-forming composition containing a solvent is applied to the release surface of the second release film 152, the release surface having a surface roughness Ra of 30 nm, with a knife coater, and then dried at 120°C for 2 minutes in an oven to form a film for forming a back surface protective film. Then, the release surface of the first release film 151 having a thickness of 38 μm , the release surface having a surface roughness Ra of 30 nm, is overlaid on the film for forming a back surface protective film to bond both films together, for example, under conditions of 23°C and 0.4 MPa, and a film for forming a back surface protective film can be produced, the film for forming a back surface protective film including the first release film 151, the film for forming a back surface protective film (the film 13 for forming a back surface protective film in Fig. 2) (thickness: 25 μm), and the second release film 152. This allows an easy release surface to be formed between the rough surface 13a of the film 13 for forming a back surface protective film and the first release film 151 and a tight release surface with a greater peel strength than the peel strength of the easy release surface to be formed between the smooth surface 13b of the film 13 for forming a back surface protective film and the second release film 152. Such a film for forming a back surface protective film is

also suitably stored, for example, in a roll form.

[0031]

The surface roughness of the first release film 151 side of the film for forming a back surface protective film can be adjusted by the conditions of the temperature and pressure for bonding the release surface of the first release film 151 to the film for forming a back surface protective film. Increasing the conditions of the temperature and pressure for bonding the release surface of the first release film 151 to the film for forming a back surface protective film allows the surface roughness of the first release film 151 side of the film for forming a back surface protective film to be faithful to the surface roughness of the release surface of the first release film 151.

[0032]

The surface roughness Ra of the rough surface of the film for forming a back surface protective film facing the back surface side of the workpiece may be from 32 to 1200 nm and is preferably from 32 to 1000 nm, more preferably from 32 to 900 nm, and particularly preferably from 32 to 800 nm.

[0033]

With a larger surface roughness Ra, the rough surface of the film for forming a back surface protective film has a substantially smaller area of contact with the release film. Thus, with the surface roughness Ra of the rough surface of the film for forming a back surface protective film not less than the lower limit described above, the rough surface side of the film for forming a back surface protective film is likely to be preferentially released when the rough surface side is peeled.

This can reduce the risk of release failure (what is called “nakiwakare”, (peeling off at an undesirable site)), in which a portion of the film for forming a back surface protective film remains on the release film having low release strength as a result of

cohesive failure or the like of the film for forming a back surface protective film caused by inappropriate release of the film for forming a back surface protective film from the release film having low release strength when the release film on the side having low release strength is peeled.

[0034]

The surface roughness Ra of the smooth surface of the film for forming a back surface protective film, the smooth surface facing the side of the support sheet, is preferably from 20 to 80 nm, more preferably from 24 to 50 nm, and even more preferably from 28 to 32 nm.

[0035]

The ratio of the surface roughness Ra of the rough surface of the film for forming a back surface protective film to the surface roughness Ra of the smooth surface of the film for forming a back surface protective film (the surface roughness Ra of the rough surface/the surface roughness Ra of the smooth surface) may be from 1.1 to 50, from 1.2 to 45, from 1.3 to 35, from 1.4 to 30, or from 1.5 to 24.

[0036]

In the second lamination illustrated in Fig. 1(d), the support sheet 10 is laminated on the smooth surface 13b of the film 13 for forming a back surface protective film laminated on the back surface 14b of the workpiece 14. The support sheet 10 is, for example, a circular polyethylene terephthalate film having a thickness of 80 μm and a diameter of 270 mm and is provided with an adhesive layer 16 for a jig on the outer peripheral part. In the present embodiment, the workpiece 14 is fixed to a fixing jig 18 together with the film 13 for forming a back surface protective film. The support sheet 10 is then laminated on the smooth surface 13b of the film 13 for forming a back surface protective film and is also fixed to the fixing jig 18 via the adhesive layer 16 for a jig

(Fig. 1(e)).

[0037]

In the related art, an apparatus for laminating the film 13 for forming a back surface protective film on the back surface 8b of the semiconductor wafer 8 in Fig. 9(A) and an apparatus for laminating the support sheet 10 on the back surface protective film 13' in Fig. 9(D) have been separate apparatuses, and a plurality of laminates obtained from each apparatus has been accommodated in a single cassette and transferred to a next apparatus.

However, in the present embodiment, at least a process from the first lamination illustrated in Fig. 1(b) to the second lamination illustrated in Fig. 1(d) is performed with an apparatus for attaching the film for forming a back surface protective film and an apparatus for attaching the support sheet being connected to each other or performed in the same apparatus. Thus, from the first lamination to the second lamination, the second laminate including the film 13 for forming a back surface protective film attached to the workpiece 14 can be transferred one by one to the second lamination illustrated in Fig. 1(d) without being accommodated in the cassette. Performing the process in the same apparatus can further reduce the apparatus space. The process is performed in the connected apparatuses, which is feasible by modifying the apparatus known in the art without designing the apparatus from scratch, and this can reduce the initial cost. Furthermore, the second laminate is not accommodated in the cassette and not transferred out of the apparatus, and thus this can improve manufacturing efficiency and prevent contamination and breakage of the second laminate.

[0038]

In the present embodiment, the peeling of the second release film 152 on the side of the smooth surface 13b from the film 13 for forming a back surface protective

film after the first lamination can also be performed with an apparatus for attaching the film for forming a back surface protective film, an apparatus for peeling the second release film, and an apparatus for attaching the support sheet being connected to each other or can also be performed in the same apparatus.

[0039]

The film 13 for forming a back surface protective film used in the first lamination may be processed in advance into the shape of the workpiece or may be processed in the same apparatus immediately before performing the first lamination. When the size of the workpiece is constant in the manufacturing line used, the former case in which the film is processed in advance, is efficient, and when the size of the workpiece can be changed, the latter case eliminates the waste of the film for forming a back surface protective film and thus has cost advantage.

[0040]

The peeling of the first release film 151 on the side of the rough surface 13a from the film 13 for forming a back surface protective film of the first laminate 5 before the first lamination can also be performed with an apparatus for peeling the first release film and an apparatus for attaching the film for forming a back surface protective film being connected to each other or can also be performed in the same apparatus.

[0041]

In the present embodiment, a transfer distance of the workpiece 14 from an attaching starting point of the first lamination to an attaching completion point of the second lamination (or from the attaching starting point of the first lamination to a curing completion point of the curing) can be designed to be 7000 mm or shorter, and the apparatus space can be reduced. The transfer distance of the workpiece 14 from the attaching starting point of the first lamination to the attaching completion point of the

second lamination (or from the attaching starting point of the first lamination to the curing completion point of the curing) can be 6500 mm or shorter, 6000 mm or shorter, 4500 mm or shorter, or 3000 mm or shorter.

[0042]

In the present embodiment, a transfer time of the workpiece 14 from an attaching starting time of the first lamination to an attaching completion time of the second lamination can be 150 s or shorter, and the process time can be shortened. The transfer time of the workpiece 14 from the attaching starting time of the first lamination to the attaching completion time of the second lamination can be 130 s or shorter, 110 s or shorter, 90 s or shorter, or 70 s or shorter.

[0043]

In the present embodiment, a transfer time of the workpiece 14 from the attaching starting time of the first lamination to the curing completion time of the curing can be 400 s or shorter, and the process time can be shortened. The transfer time of the workpiece 14 from the attaching starting time of the first lamination to the curing completion time of the curing can be 300 s or shorter, 250 s or shorter, 200 s or shorter, or 150 s or shorter.

[0044]

The speed at which the rough surface 13a of the film 13 for forming a back surface protective film is attached to the back surface 14b of the workpiece 14 in the first lamination in the method of manufacturing the third laminate and a speed at which the support sheet 10 is attached to the smooth surface 13b of the film 13 for forming a back surface protective film in the second lamination in the method of manufacturing the third laminate can be 100 mm/s or lower, 80 mm/s or lower, 60 mm/s or lower, or 40 mm/s or lower. With the speed of the attaching in the first lamination and the speed of the

attaching in the second lamination not higher than the upper limit described above, the method can achieve good adherence between the workpiece 14 and the film 13 for forming a back surface protective film and between the film 13 for forming a back surface protective film and the support sheet 10.

[0045]

The speed of the attaching in the first lamination and the speed of the attaching in the second lamination can be 2 mm/s or higher, 5 mm/s or higher, or 10 mm/s or higher. With the speed of the attaching in the first lamination and the speed of the attaching in the second lamination not lower than the lower limit described above, the method can improve the production efficiency of the second laminate 6 and the third laminate 19, shorten the transfer time of the workpiece 14 from the attaching starting time of the first lamination to the attaching completion time of the second lamination to 150 s or shorter, and shorten the transfer time of the workpiece 14 from the attaching starting time of the first lamination to the curing completion time of the curing to 400 s or shorter.

[0046]

The transfer distance of the workpiece from the attaching starting point of the first lamination according to the present embodiment illustrated in Fig. 1(b) to the attaching completion point of the second lamination illustrated in Fig. 1(d) can be 7000 mm or shorter, 6500 mm or shorter, 6000 mm or shorter, 4500 mm or shorter, or 3000 mm or shorter. The transfer time of the workpiece from the attaching starting time of the first lamination according to the present embodiment illustrated in Fig. 1(b) to the attaching completion time of the second lamination illustrated in Fig. 1(d) can be 150 s or shorter, 130 s or shorter, or 110 s or shorter.

[0047]

In addition, the transfer distance of the workpiece from the attaching starting point of the first lamination according to the present embodiment illustrated in Fig. 1(b) to the curing completion point of the curing illustrated in Fig. 4(g) can be 7000 mm or shorter, 6500 mm or shorter, 6000 mm or shorter, 4500 mm or shorter, or 3000 mm or shorter.

The transfer time of the workpiece 14 from the attaching starting point of the first lamination according to the present embodiment illustrated in Fig. 1(b) to the curing completion point of the curing illustrated in Fig. 4(g) can be 400 s or shorter, 300 s or shorter, 250 s or shorter, 200 s or shorter, or 150 s or shorter.

[0048]

(Protective film-forming composition)

The composition of the protective film-forming composition for forming the film for forming a back surface protective film preferably contains a binder polymer component and a curable component.

[0049]

(Binder polymer component)

The binder polymer component is used to impart sufficient adhesion and film formability (sheet formability) to the film for forming a back surface protective film. For the binder polymer component, a polymer known in the art, such as an acrylic polymer, a polyester resin, a urethane resin, an acrylic urethane resin, a silicone resin, or a rubber polymer, can be used.

[0050]

The weight average molecular weight (M_w) of the binder polymer component is preferably from 10000 to 2000000 and more preferably from 100000 to 1200000. With an extremely low weight average molecular weight of the binder polymer component, the

adhesion strength between the film for forming a back surface protective film and the support sheet would increase, and this may cause transfer failure of the film for forming a back surface protective film, while with an extremely high weight average molecular weight, the adhesion of the film for forming a back surface protective film would decrease, and the film for forming a back surface protective film may fail to be transferred to a chip or the like or may peel off from a chip or the like after transfer.

[0051]

An acrylic polymer is preferably used as the binder polymer component. The glass transition temperature (T_g) of the acrylic polymer is in a range preferably of -60 to 50°C , more preferably of -50 to 40°C , and particularly preferably of -40 to 30°C . In a case of the acrylic polymer having an extremely low glass transition temperature, the release strength between the film for forming a back surface protective film and the support sheet would increase, and this may cause transfer failure of the film for forming a back surface protective film, while in a case of the acrylic polymer having an extremely high glass transition temperature, the adhesion of the film for forming a back surface protective film would decrease, and the film for forming a back surface protective film may fail to be transferred to a chip or the like or may peel off from a chip or the like after transfer.

[0052]

Examples of the monomer constituting the acrylic polymer include (meth)acrylic ester monomers or their derivatives. Examples include alkyl(meth)acrylates with an alkyl group having from 1 to 18 carbon atoms, specifically methyl(meth)acrylate, ethyl(meth)acrylate, propyl(meth)acrylate, butyl(meth)acrylate, and 2-ethylhexyl(meth)acrylate. In addition, examples include (meth)acrylates having a cyclic backbone, specifically cyclohexyl(meth)acrylate, benzyl(meth)acrylate,

isobornyl(meth)acrylate, dicyclopentanyl(meth)acrylate, dicyclopentenyl(meth)acrylate, dicyclopentenylmethoxyethyl(meth)acrylate, and imide(meth)acrylate. Furthermore, examples of the monomer having a functional group include hydroxymethyl(meth)acrylate, 2-hydroxyethyl(meth)acrylate, and 2-hydroxypropyl(meth)acrylate, which have a hydroxyl group; and in addition, glycidyl(meth)acrylate, which has an epoxy group. The acrylic polymer is preferably an acrylic polymer containing a monomer having a hydroxyl group because of good compatibility with the curable component described later. In addition, the acrylic polymer may be a polymer copolymerized with acrylic acid, methacrylic acid, itaconic acid, vinyl acetate, acrylonitrile, styrene, or the like.

[0053]

Furthermore, the protective film-forming composition may contain a thermoplastic resin to retain the flexibility of the protective film after curing as the binder polymer component. Such a thermoplastic resin has a weight average molecular weight preferably from 1000 to 100000 and more preferably from 3000 to 80000. The glass transition temperature of the thermoplastic resin is preferably from -30 to 120°C and more preferably from -20 to 120°C. Examples of the thermoplastic resin include polyester resins, urethane resins, phenoxy resins, polybutenes, polybutadienes, and polystyrenes. One of these thermoplastic resins can be used alone, or two or more can be used as a mixture. The protective film-forming composition containing the thermoplastic resin described above allows the film for forming a back surface protective film to conform to a transfer surface of the film for forming a back surface protective film and can prevent the occurrence of a void or the like.

[0054]

(Curable component)

For the curable component, a thermosetting component and/or an energy ray-

curable component is used.

[0055]

For the thermosetting component, a thermosetting resin and a thermosetting agent are used. The thermosetting resin is, for example, preferably an epoxy resin.

[0056]

For the epoxy resin, an epoxy resin known in the art can be used. Examples of the epoxy resin specifically include epoxy compounds having two or more functional groups in the molecule, such as multifunctional epoxy resins, biphenyl compounds, bisphenol A diglycidyl ethers and their hydrogenated products, ortho-cresol novolac epoxy resins, dicyclopentadiene-type epoxy resins, biphenyl-type epoxy resins, bisphenol A-type epoxy resins, bisphenol F-type epoxy resins, and phenylene backbone-type epoxy resins. One of these can be used alone, or two or more can be used in combination.

[0057]

The film for forming a back surface protective film contains preferably from 1 to 1000 parts by mass, more preferably from 10 to 500 parts by mass, and particularly preferably from 20 to 200 parts by mass of the thermosetting resin relative to 100 parts by mass of the binder polymer component. The thermosetting resin contained in an amount less than 1 part by mass may fail to provide sufficient adhesion, while the thermosetting resin contained in an amount exceeding 1000 parts by mass may increase the release strength between the film for forming a back surface protective film and a pressure sensitive adhesive (PSA) sheet or a substrate film and may cause transfer failure of the film for forming a back surface protective film.

[0058]

The thermosetting agent functions as a curing agent for the thermosetting resin, particularly for the epoxy resin. Examples of the preferred thermosetting agent include

compounds having two or more functional groups reactive with an epoxy group per molecule. Examples of the functional group include a phenolic hydroxyl group, an alcoholic hydroxyl group, an amino group, a carboxyl group, and an acid anhydride. Of these, examples preferably include a phenolic hydroxyl group, an amino group, and an acid anhydride, and more preferably include a phenol hydroxyl group and an amino group.

[0059]

Specific examples of the phenolic curing agent include multifunctional phenolic resins, biphenol, novolak-type phenolic resins, dicyclopentadiene phenolic resins, Xylok-type phenolic resins, and aralkyl phenolic resins. Specific examples of the amine curing agent include dicyandiamide (DICY). One of these can be used alone, or two or more can be used as a mixture.

[0060]

The content of the thermosetting agent is preferably from 0.1 to 500 parts by mass and more preferably from 1 to 200 parts by mass relative to 100 parts by mass of the thermosetting resin. With a small content of the thermosetting agent, the film for forming a back surface protective film may fail to have sufficient adhesion because of insufficient curing, while with an excessive amount of the thermosetting agent, the film for forming a back surface protective film would have an increased moisture absorption rate, and this may reduce the reliability of the semiconductor device.

[0061]

For the energy ray-curable component, a low molecular compound that contains an energy ray-polymerizable group and polymerizes and cures upon irradiation with an energy ray, such as ultraviolet light or an electron beam, (an energy ray-polymerizable compound) can be used. Specific examples of such an energy ray-curable component

include acrylate compounds, such as trimethylolpropane triacrylate, pentaerythritol triacrylate, pentaerythritol tetraacrylate, dipentaerythritol monohydroxy pentaacrylate, dipentaerythritol hexaacrylate or 1,4-butylene glycol diacrylate, 1,6-hexanediol diacrylate, polyethylene glycol diacrylate, oligoester acrylate, urethane acrylate oligomer, epoxy-modified acrylate, polyether acrylate, and itaconic acid oligomer. Such compounds have at least one polymerizable double bond in the molecule and have a weight average molecular weight typically from 100 to 30000 and preferably from approximately 300 to 10000. A blended amount of the energy ray-polymerizable compound is preferably from 1 to 1500 parts by mass, more preferably from 10 to 500 parts by mass, and particularly preferably from 20 to 200 parts by mass relative to 100 parts by mass of the binder polymer component.

[0062]

In addition, for the energy ray-curable component, an energy ray-curable polymer in which an energy ray-polymerizable group is bonded to a main chain or side chain of the binder polymer component may be used. Such an energy ray-curable polymer has both functions as a binder polymer component and as a curable component.

[0063]

The main backbone of the energy ray-curable polymer is not particularly limited and may be an acrylic polymer widely used as a binder polymer component and may be a polyester, polyether, or the like, but an acrylic polymer is particularly preferably used as the main backbone because of ease of control of the synthesis and physical properties.

[0064]

The energy ray-polymerizable group bonded to a main chain or side chain of the energy ray-curable polymer is, for example, a group containing an energy ray-polymerizable carbon-carbon double bond and is specifically exemplified by a

(meth)acryloyl group. The energy ray-polymerizable group may be a group bonded to the energy ray-curable polymer via an alkylene group, an alkyleneoxy group, or a polyalkyleneoxy group.

[0065]

The weight average molecular weight (Mw) of the energy ray-curable polymer to which the energy ray-polymerizable group is bonded is preferably from 10000 to 2000000 and more preferably from 100000 to 1500000. In addition, the glass transition temperature (Tg) of the energy ray-curable polymer is in a range preferably of -60 to 50°C, more preferably of -50 to 40°C, and particularly preferably of -40 to 30°C.

[0066]

The energy ray-curable polymer is obtained, for example, by reacting an acrylic polymer containing a functional group, such as a hydroxyl group, a carboxyl group, an amino group, a substituted amino group, or an epoxy group; and a polymerizable group-containing compound having a substituent reactive with the functional group and from 1 to 5 energy ray-polymerizable carbon-carbon double bonds per molecule. Examples of the substituent reactive with the functional group include a isocyanate group, a glycidyl group, and a carboxyl group.

[0067]

Examples of the polymerizable group-containing compound include (meth)acryloyloxyethyl isocyanate, meta-isopropenyl- α,α -dimethylbenzyl isocyanate, (meth)acryloyl isocyanate, allyl isocyanate, glycidyl(meth)acrylate, and (meth)acrylic acid.

[0068]

The acrylic polymer is preferably a copolymer composed of a (meth)acrylic monomer or its derivative having a functional group, such as a hydroxyl group, a

carboxyl group, an amino group, a substituted amino group, or an epoxy group; and another (meth)acrylic ester monomer or its derivative copolymerizable with the monomer described above.

[0069]

Examples of the (meth)acrylic monomer or its derivative having a functional group, such as a hydroxyl group, a carboxyl group, an amino group, a substituted amino group, or an epoxy group include 2-hydroxyethyl (meth)acrylate and 2-hydroxypropyl (meth)acrylate, which have a hydroxyl group; acrylic acid, methacrylic acid, and itaconic acid, which have a carboxyl group; and glycidyl methacrylate and glycidyl acrylate, which have an epoxy group.

[0070]

Examples of another (meth)acrylic ester monomer or its derivative copolymerizable with the monomer described above include alkyl(meth)acrylates with an alkyl group having from 1 to 18 carbon atoms, specifically methyl(meth)acrylate, ethyl(meth)acrylate, propyl(meth)acrylate, butyl(meth)acrylate, and 2-ethylhexyl(meth)acrylate; (meth)acrylates having a cyclic backbone, specifically cyclohexyl(meth)acrylate, benzyl(meth)acrylate, isobornyl acrylate, dicyclopentanyl acrylate, dicyclopentenyl acrylate, dicyclopentenyl oxyethyl acrylate, and imide acrylate. In addition, the acrylic polymer may be a polymer copolymerized with vinyl acetate, acrylonitrile, styrene, or the like.

[0071]

Even when an energy ray-curable polymer is used, the energy ray-polymerizable compound described above may be used in combination, and the binder polymer component may be used in combination. The relationship between the blended amounts of these three compounds in the film for forming a back surface protective film in the

present invention is that the energy ray-polymerizable compound is in an amount preferably from 1 to 1500 parts by mass, more preferably from 10 to 500 parts by mass, and particularly preferably from 20 to 200 parts by mass relative to 100 parts by mass of the sum of the masses of the energy ray-curable polymer and the binder polymer component.

[0072]

Imparting energy ray-curability to the film for forming a back surface protective film allows the film for forming a back surface protective film to be easily cured in a short time, improving the production efficiency of chips with a protective film. A protective film for a chip has typically been formed from a thermosetting resin, such as an epoxy resin, in the related art, but the cure temperature of the thermosetting resin exceeds 200°C, and the cure time is approximately 2 hours, and thus these have been stumbling blocks in improving the production efficiency. However, the energy ray-curable film for forming a back surface protective film is cured in a short time by energy ray irradiation, thus can easily form the protective film and contribute to improved production efficiency.

[0073]

The film for forming a back surface protective film can contain a component below in addition to the binder polymer component and the curable component.

[0074]

(Colorant)

The film for forming a back surface protective film preferably contains a colorant. When a semiconductor device is incorporated into a device, the film for forming a back surface protective film containing a colorant blocks infrared light or the like generated from a surrounding device and can prevent a malfunction of the

semiconductor device caused by the infrared light or the like. In addition, this improves visibility of a letter when a product number or the like is marked on the protective film obtained by curing the film for forming a back surface protective film. That is, in a semiconductor device or semiconductor chip on which a protective film is formed, a product number or the like is marked on the surface of the protective film typically by a laser marking method (a method of marking by scraping the surface of the protective film with laser light); and the protective film containing a colorant allows a sufficient contrast differences between the portion scraped with laser light and the portion not scraped in the protective film to be obtained and improves the visibility. For the colorant, an organic or inorganic pigment and dye are used. Of these, a black pigment is preferred from the viewpoint of blocking properties against an electromagnetic wave or infrared light. For the black pigment, carbon black, iron oxide, manganese dioxide, aniline black, activated carbon, or the like is used, but the black pigment is not limited to these. From the viewpoint of improving the reliability of the semiconductor device, carbon black is particularly preferred. One of the colorants may be used alone, or two or more may be used in combination. The high curability of the film for forming a back surface protective film in the present invention is particularly preferably exhibited when a colorant reducing the transmissivity of visible light and/or both infrared light and ultraviolet light is used and the transmissivity of ultraviolet light is reduced. In addition to the black pigment described above, the colorant reducing the transmissivity of visible light and/or both infrared light and ultraviolet light is not particularly limited as long as the colorant has absorbency or reflectivity in the wavelength region of visible light and/or both infrared light and ultraviolet light.

[0075]

A blended amount of the colorant is preferably from 0.1 to 35 parts by mass,

more preferably from 0.5 to 25 parts by mass, and particularly preferably from 1 to 15 parts by mass relative to 100 parts by mass of a total solid content constituting the film for forming a back surface protective film.

[0076]

(Curing accelerator)

A curing accelerator is used to adjust the curing rate of the film for forming a back surface protective film. The curing accelerator is preferably used particularly when an epoxy resin and a thermosetting agent are used in combination in the curable component.

[0077]

Examples of a preferred curing accelerator include tertiary amines, such as triethylenediamine, benzyldimethylamine, triethanolamine, dimethylaminoethanol, and tris(dimethylaminomethyl)phenol; imidazoles, such as 2-methylimidazole, 2-phenylimidazole, 2-phenyl-4-methylimidazole, 2-phenyl-4,5-dihydroxymethylimidazole, and 2-phenyl-4-methyl-5-hydroxymethylimidazole; organic phosphines, such as tributylphosphine, diphenylphosphine, and triphenylphosphine; and tetraphenylboron salts, such as tetraphenylphosphonium tetraphenylborate and triphenylphosphine tetraphenylborate. One of these can be used alone, or two or more can be used as a mixture.

[0078]

The curing accelerator is in an amount preferably from 0.01 to 10 parts by mass and more preferably from 0.1 to 1 part by mass relative to 100 parts by mass of the curable component. The film for forming a back surface protective film containing the curing accelerator in the above range has excellent adhesive properties even when exposed to high temperature and high humidity conditions and can achieve high

reliability even when exposed to severe reflow conditions. With a small content of the curing accelerator, the film for forming a back surface protective film would fail to have sufficient adhesive properties because of insufficient curing, while with an excessive amount, the curing accelerator, which has high polarity, would migrate through the film for forming a back surface protective film to the adhesive interface side under high temperature and high humidity and segregate there, and this would reduce the reliability of the semiconductor device.

[0079]

(Coupling agent)

A coupling agent may be used to improve the adhesion and adherence of the film for forming a back surface protective film to a chip and/or cohesiveness of the protective film. In addition, use of a coupling agent can improve water resistance of the protective film obtained by curing the film for forming a back surface protective film without impairing heat resistance of the protective film.

[0080]

For the coupling agent, a compound having a group reactive with a functional group contained in the binder polymer component, the curable component, or the like is preferably used. The coupling agent is desirably a silane coupling agent. Examples of such a coupling agent include γ -glycidoxypropyltrimethoxysilane, γ -glycidoxypropylmethyldiethoxysilane, β -(3,4-epoxycyclohexyl)ethyltrimethoxysilane, γ -(methacryloxypropyl)trimethoxysilane, γ -aminopropyltrimethoxysilane, N-6-(aminoethyl)- γ -aminopropyltrimethoxysilane, N-6-(aminoethyl)- γ -aminopropylmethyldiethoxysilane, N-phenyl- γ -aminopropyltrimethoxysilane, γ -ureidopropyltriethoxysilane, γ -mercaptopropyltrimethoxysilane, γ -mercaptopropylmethyldimethoxysilane, bis(3-triethoxysilylpropyl)tetrasulfane,

methytrimethoxysilane, methyltriethoxysilane, vinyltrimethoxysilane, vinyltriacetoxysilane, and imidazole silane. One of these can be used alone, or two or more can be used as a mixture.

[0081]

The coupling agent is in a proportion typically of 0.1 to 20 parts by mass, preferably from 0.2 to 10 parts by mass, and more preferably from 0.3 to 5 parts by mass relative to a total of 100 parts by mass of the binder polymer component and the curable component. With the content of the coupling agent less than 0.1 parts by mass, the method would fail to provide the effects described above, while the coupling agent contained in an amount exceeding 20 parts by mass would cause outgassing.

[0082]

(Inorganic filler)

With the film for forming a back surface protective film containing an inorganic filler, the method can adjust the thermal expansion coefficient of the protective film after curing, optimize the thermal expansion coefficient of the protective film after curing for a semiconductor chip, and improve the reliability of the semiconductor device. In addition, this can also reduce the moisture absorption rate of the protective film after curing.

[0083]

Examples of a preferred inorganic filler include powders of silica, alumina, talc, calcium carbonate, titanium oxide, iron oxide, silicon carbide, boron nitride, or the like; spheronized beads; single crystal fibers; and glass fibers thereof. Of these, silica fillers and alumina fillers are preferred. The inorganic filler can be used alone or as a mixture of two or more. The content of the inorganic filler can be adjusted in a range typically of 1 to 80 parts by mass relative to 100 parts by mass of a total solid content constituting the film for forming a back surface protective film.

[0084]

(Photopolymerization Initiator)

The film for forming a back surface protective film containing the energy ray-curable component as the curable component described above is irradiated with an energy ray, such as ultraviolet light, to cure the energy ray-curable component when the film is used. At this time, the composition containing a photopolymerization initiator can reduce the polymerization cure time and the light irradiation amount.

[0085]

Examples of such a photopolymerization initiator specifically include benzophenone, acetophenone, benzoin, benzoin methyl ether, benzoin ethyl ether, benzoin isopropyl ether, benzoin isobutyl ether, benzoinbenzoic acid, methyl benzoinbenzoate, benzoin dimethyl ketal, 2,4-diethylthioxanthone, α -hydroxycyclohexyl phenyl ketone, benzyldiphenyl sulfide, tetramethylthiuram monosulfide, azobisisobutyronitrile, benzyl, dibenzyl, diacetyl, 1,2-diphenylmethane, 2-hydroxy-2-methyl-1-[4-(1-methylvinyl)phenyl]propanone, 2,4,6-trimethylbenzoyldiphenylphosphine oxide, and β -chloroanthraquinone. The photopolymerization initiator can be used alone or in combination of two or more.

[0086]

The blending proportion of the photopolymerization initiator is preferably from 0.1 to 10 parts by mass and more preferably from 1 to 5 parts by mass relative to 100 parts by mass of the energy ray-curable component. With the proportion less than 0.1 parts by mass, the method may fail to provide satisfactory transfer properties because of insufficient photopolymerization, while with the proportion exceeding 10 parts by mass, a residue not contributing to photopolymerization would be produced, and this may result in insufficient curability of the film for forming a back surface protective film.

[0087]

(Crosslinking agent)

A crosslinking agent can also be added to adjust the initial adhesive strength and cohesive strength of the film for forming a back surface protective film. Examples of the crosslinking agent include organic polyvalent isocyanate compounds and organic polyvalent imine compounds.

[0088]

Examples of the organic polyvalent isocyanate compound include aromatic polyvalent isocyanate compounds, aliphatic polyvalent isocyanate compounds, alicyclic polyvalent isocyanate compounds, and trimers of these organic polyvalent isocyanate compounds; and terminal isocyanate urethane prepolymers obtained by reacting these organic polyvalent isocyanate compounds and a polyol compound.

[0089]

Examples of the organic polyvalent isocyanate compound include 2,4-tolylene diisocyanate, 2,6-tolylene diisocyanate, 1,3-xylylene diisocyanate, 1,4-xylylene diisocyanate, diphenylmethane-4,4'-diisocyanate, diphenylmethane-2,4'-diisocyanate, 3-methyldiphenylmethane diisocyanate, hexamethylene diisocyanate, isophorone diisocyanate, dicyclohexylmethane-4,4'-diisocyanate, dicyclohexylmethane-2,4'-diisocyanate, trimethylolpropane adduct tolylene diisocyanate, and lysine isocyanate.

[0090]

Examples of the organic polyvalent imine compound include N,N'-diphenylmethane-4,4'-bis(1-aziridinecarboxamide), trimethylolpropane-tri- β -aziridinyl propionate, tetramethylolmethane-tri- β -aziridinyl propionate, and N,N'-toluene-2,4-bis(1-aziridinecarboxamide)triethylenemelamine.

[0091]

The crosslinking agent is used at a ratio typically from 0.01 to 20 parts by mass, preferably from 0.1 to 10 parts by mass, and more preferably from 0.5 to 5 parts by mass relative to a total of 100 parts by mass of the binder polymer component and the energy ray-curable polymer.

[0092]

(Versatile additive)

The film for forming a back surface protective film may contain an additive of various types as necessary in addition to the above. Examples of the additive of various types include leveling agents, plasticizers, antistatic agents, antioxidants, ion scavengers, gettering agents, and chain transfer agents.

[0093]

(Solvent)

The protective film-forming composition preferably further contains a solvent. The protective film-forming composition containing a solvent has good handling properties.

The solvent is not particularly limited, but preferred examples include hydrocarbons, such as toluene and xylene; alcohols, such as methanol, ethanol, 2-propanol, isobutyl alcohol (2-methylpropan-1-ol), and 1-butanol; esters, such as ethyl acetate; ketones, such as acetone and methyl ethyl ketone; ethers, such as tetrahydrofuran; and amides, such as dimethylformamide and N-methylpyrrolidone (compounds having an amide bond).

A protective film-forming composition may contain only one solvent or two or more. When two or more solvents are contained, the combination and ratio can be freely selected.

[0094]

The solvent in the protective film-forming composition is preferably methyl

ethyl ketone or the like from the viewpoint that components contained in the protective film-forming composition can be more uniformly mixed.

[0095]

The film for forming a back surface protective film obtained by applying and drying the protective film-forming composition composed of the components as described above has adhesion and curability and is easily adhered in an uncured state by pressing onto a workpiece (such as a semiconductor wafer or a chip). When pressed, the film for forming a back surface protective film may be heated. In addition, a protective film with high impact resistance can be ultimately provided through curing, and the protective film also has excellent adhesive strength and can retain a sufficient protective function even under severe high temperature and high humidity conditions. The film for forming a back surface protective film may have a single layer structure, or may have a multilayer structure as long as the film contains one or more layers containing the components described above.

[0096]

The thickness of the film for forming a back surface protective film is not particularly limited but is preferably from 3 to 300 μm , more preferably from 5 to 250 μm , and particularly preferably from 7 to 200 μm .

[0097]

(Support sheet)

Examples of the support sheet 10 used in an aspect of the present invention include a sheet constituted only of a substrate 11, and a PSA sheet having a pressure sensitive adhesive layer 12 on the substrate 11.

The support sheet included in the third laminate according to an aspect of the present invention may serve as a release sheet for preventing adherence of dust or the like

on the surface of the film for forming a back surface protective film, or a dicing sheet for protecting the surface of the film for forming a back surface protective film in dicing or the like.

[0098]

The thickness of the support sheet is appropriately selected according to the application, but from the viewpoint of imparting sufficient flexibility to a composite sheet and providing good attaching to a silicon wafer, the thickness is preferably from 10 to 500 μm , more preferably from 20 to 350 μm , and even more preferably from 30 to 200 μm .

The thickness of the support sheet described above includes not only the thickness of the substrate constituting the support sheet but also the thicknesses of a layer and a film when the support sheet has a pressure sensitive adhesive layer.

[0099]

(Substrate)

The substrate 11 constituting the support sheet 10 is preferably a resin film.

Examples of the resin film include polyethylene films, such as low density polyethylene (LDPE) films and linear low density polyethylene (LLDPE) films; ethylene-propylene copolymer films; polypropylene films; polybutene films; polybutadiene films; polymethylpentene films; polyvinyl chloride films; vinyl chloride copolymer films; polyethylene terephthalate films; polyethylene naphthalate films; polybutylene terephthalate films; polyurethane films, ethylene-vinyl acetate copolymer films; ionomer resin films; ethylene-(meth)acrylic acid copolymer films; ethylene-(meth)acrylic ester copolymer films; polystyrene films; polycarbonate films; polyimide films; and fluorine resin films.

The substrate used in an aspect of the present invention may be a single layer

film composed of one resin film or may be a laminated film in which two or more resin films are laminated.

In addition, in an aspect of the present invention, a sheet surface-treated on the surface of the substrate, such as the resin film described above, may be used as the support sheet.

[0100]

These resin films may be crosslinked films.

In addition, resin films prepared by subjecting these resin films to coloring, printing, or the like can also be used. Further, the resin film may be a sheet obtained by extruding a thermoplastic resin or may be a stretched resin film, or a sheet obtained by thinning and curing a curable resin by a given means may be used.

[0101]

Of these resin films, a substrate containing a polypropylene film is preferred from the viewpoint of having excellent heat resistance, having expansion suitability to have moderate flexibility, and easily maintaining pickup suitability.

The configuration of the substrate containing a polypropylene film may be a single layer structure composed only of a polypropylene film or may be a multilayer structure composed of a polypropylene film and another resin film.

When the film for forming a back surface protective film is thermosetting, the resin film constituting the substrate has heat resistance, thus prevents damage due to heat of the substrate, and can prevent the occurrence of a defect in the manufacturing process of the semiconductor device.

[0102]

When a sheet constituted only of a substrate is used as the support sheet, the surface tension of the surface of the substrate coming into contact with the surface of the

film for forming a back surface protective film is preferably from 20 to 50 mN/m, more preferably from 23 to 45 mN/m, and even more preferably from 25 to 40 mN/m from the viewpoint of adjusting the release strength to a certain range.

[0103]

The thickness of the substrate constituting the support sheet is preferably from 10 to 500 μm , more preferably from 15 to 300 μm , and even more preferably from 20 to 200 μm .

[0104]

(PSA sheet)

Examples of the PSA sheet used as the support sheet 10 in an aspect of the present invention include a sheet having the pressure sensitive adhesive layer 12 formed from a pressure sensitive adhesive on the substrate 11, such as the resin film described above.

Fig. 11 is a schematic cross-sectional view illustrating an example of the support sheet 10 provided with the pressure sensitive adhesive layer 12 on the substrate 11.

When the support sheet 10 is provided with the pressure sensitive adhesive layer 12, the pressure sensitive adhesive layer 12 of the support sheet 10 is attached to the smooth surface 13b of the film 13 for forming a back surface protective film in the second lamination.

[0105]

Examples of the pressure sensitive adhesive used as a material for forming the pressure sensitive adhesive layer include a pressure sensitive adhesive composition containing a pressure sensitive adhesive resin, and the pressure sensitive adhesive composition may further contain a versatile additive, such as the crosslinking agent or tackifier described above.

Examples of the pressure sensitive adhesive resin, when attention is paid to the structure of the resin, include acrylic resins, urethane resins, rubber resins, silicone resins, vinyl ether resins, while when attention is paid to the function of the resin, examples include energy ray-curable pressure sensitive adhesives, heat-foaming pressure sensitive adhesives, and energy ray-foaming pressure sensitive adhesives.

In an aspect of the present invention, from the viewpoint of adjusting the release strength to a certain range and from the viewpoint of providing good pick-up properties, the PSA sheet is preferably a PSA sheet having an energy ray-curable pressure sensitive adhesive layer formed from a pressure sensitive adhesive composition containing an energy ray-curable resin or a PSA sheet having a pressure sensitive adhesive layer with slight pressure sensitive adhesion.

The energy ray-curable resin is a resin having a polymerizable group, such as a (meth)acryloyl group or a vinyl group, but is preferably a pressure sensitive adhesive resin having a polymerizable group.

[0106]

The support sheet can also serve as a sheet for releasing the film for forming a back surface protective film in case of attachment failure of the film for forming a back surface protective film occurs in the first lamination. Examples of such failures are (a) the film for forming a back surface protective film is not attached to the entire surface of the workpiece, such as a semiconductor wafer or the like; (b) lifting of the film for forming a back surface protective film occurs; and (c) a wrinkle or the like occurs in the film for forming a back surface protective film. Even if attachment failure of the film for forming a back surface protective film occurs in the first lamination, the film is subjected to the second lamination as it is to manufacture the third laminate. Thereafter, the film for forming a back surface protective film is detached together with the support sheet from

the workpiece, such as a semiconductor wafer, thus allowing the workpiece, such as a semiconductor wafer, to be reworked. At this time, in consideration of the production takt time, the support sheet needs to be quickly peeled from the fixing jig, such as a ring frame, and the adhesive layer for a jig is preferably energy ray-curable. In addition, using the support sheet provided with the energy ray-curable pressure sensitive adhesive layer on the substrate allows the support sheet to be directly fixed to the fixing jig, such as a ring frame, without using the adhesive layer for the jig for fixing, and the irradiation with an energy ray, such as ultraviolet light, can provide excellent reworkability.

[0107]

Furthermore, from the viewpoint of adjusting the release strength to a certain range, a pressure sensitive adhesive containing an acrylic resin is preferred.

The acrylic resin is preferably an acrylic polymer having a constituent unit (x1) derived from an alkyl(meth)acrylate and more preferably an acrylic copolymer having the constituent unit (x1) and a constituent unit (x2) derived from a functional group-containing monomer.

[0108]

The alkyl group contained in the alkyl(meth)acrylate has preferably from 1 to 18, more preferably from 1 to 12, and even more preferably from 1 to 8 carbon atoms.

Examples of the alkyl(meth)acrylate include the same alkyl(meth)acrylates described in the above section of the binder polymer component.

The alkyl(meth)acrylate may be used alone or in combination of two or more.

The content of the constituent unit (x1) is typically from 50 to 100 mass%, preferably from 50 to 99.9 mass%, more preferably from 60 to 99 mass%, and even more preferably from 70 to 95 mass% relative to all constituent units (100 mass%) of the acrylic polymer.

[0109]

Examples of the functional group-containing monomer include hydroxy group-containing monomers, carboxy group-containing monomers, and epoxy group-containing monomers, and specific examples of each monomer are the same as those exemplified in the section of the binder polymer component.

These may be used alone or in combination of two or more.

The content of the constituent unit (x2) is typically from 0 to 40 mass%, preferably from 0.1 to 40 mass%, more preferably from 1 to 30 mass%, and even more preferably from 5 to 20 mass% relative to all constituent units (100 mass%) of the acrylic polymer.

[0110]

In addition, the acrylic resin used in an aspect of the present invention may be an energy ray-curable acrylic resin obtained by reacting the acrylic copolymer having the constituent units (x1) and (x2) further with a compound having an energy ray-polymerizable group.

The compound having an energy ray-polymerizable group is a compound having a polymerizable group, such as a (meth)acryloyl group or a vinyl group.

[0111]

The pressure sensitive adhesive containing an acrylic resin when used preferably contains a crosslinking agent together with the acrylic resin from the viewpoint of adjusting the release strength to a certain range.

Examples of the crosslinking agent include isocyanate crosslinking agents, imine crosslinking agents, epoxy crosslinking agents, oxazoline crosslinking agents, and carbodiimide crosslinking agents, but isocyanate crosslinking agents are preferred from the viewpoint of adjusting the release strength to a certain range.

The content of the crosslinking agent is preferably from 0.01 to 20 parts by mass, more preferably from 0.1 to 15 parts by mass, even more preferably from 0.5 to 10 parts by mass, and still more preferably from 1 to 8 parts by mass relative to a total mass (100 parts by mass) of the acrylic resin contained in the pressure sensitive adhesive.

[0112]

The support sheet 10 may be composed of one layer (single layer) or may be composed of two or more layers (multiple layers). In the support sheet composed of multiple layers, the constituent materials and thicknesses of these multiple layers may be identical to each other or different from each other, and the combination of these multiple layers is not particularly limited as long as the effects of the present invention are not impaired.

[0113]

In the present specification, “multiple layers may be identical to each other or different from each other” means that “all layers may be identical, all layers may be different, or only some layers may be identical”, and furthermore, “multiple layers are different from each other” means that “at least one of the constituent materials or thicknesses of each layer is different from each other”, and this is not only the case of the support sheet.

[0114]

The support sheet may be transparent or opaque and may be colored according to the purpose.

For example, for the film for forming a back surface protective film having energy ray-curability, the support sheet preferably transmits an energy ray.

For example, to optically inspect the film for forming a back surface protective film through the support sheet, the support sheet is preferably transparent.

[0115]

In the present embodiment, the circuit surface 14a of the workpiece 14 is protected with the tape 17 for protecting a circuit surface, and the method can include peeling the tape 17 for protecting a circuit surface from the circuit surface 14a of the workpiece 14 after the second lamination. In the present embodiment, the tape 17 for protecting a circuit surface has an energy ray-curable pressure sensitive adhesive layer on the side affixed to the circuit surface 14a, the energy ray-curable pressure sensitive adhesive layer being cured and becoming removable by irradiation with an energy ray. In the peeling, the tape 17 for protecting a circuit surface can be easily peeled from the circuit surface 14a of the workpiece 14 by irradiating the pressure sensitive adhesive layer of the tape 17 for protecting a circuit surface with an energy ray to cure the pressure sensitive adhesive layer and make the layer removable.

[0116]

The method of manufacturing the third laminate according to the present embodiment may include irradiating the film 13 for forming a back surface protective film with a laser from the side of the support sheet 10 to create a laser marking on the film 13 for forming a back surface protective film. In the method of manufacturing a third laminate according to the present embodiment, the support sheet 10 is laminated on the smooth surface 13b of the film 13 for forming a back surface protective film, thus irradiation with a laser from the side of the support sheet 10 through the support sheet results in creation of a laser marking on the smooth surface 13b of the film 13 for forming a back surface protective film, and this allows the clearer laser marking compared to the laser marking on the rough surface 13a.

[0117]

In an example of a method of manufacturing a semiconductor chip with a back

surface protective film known in the art illustrated in Fig. 10, the smooth surface 13b of the film 13 for forming a back surface protective film of a composite sheet 1 for forming a protective film is affixed to the back surface 8b of the semiconductor wafer 8 in Fig. 10(A'), thus irradiation with a laser from the side of the support sheet 10 through the support sheet in Fig. 10(D') results in creation of the laser marking on the rough surface 13a of the film 13 for forming a back surface protective film. This impairs adherence of the interface between the rough surface 13a of the film 13 for forming a back surface protective film and the support sheet 10, thus irradiation with a laser through the support sheet results in a blurred outline of a letter or symbol marked at the interface between the film 13 for forming a back surface protective film and the support sheet 10 at a location irradiated with a laser and impairing the visibility after marking.

[0118]

On the other hand, in the method of manufacturing a third laminate according to the present embodiment, the support sheet 10 is laminated on the smooth surface 13b of the film 13 for forming a back surface protective film, and thus this maintains good adherence of the interface between the smooth surface 13b of the film 13 for forming a back surface protective film and the support sheet 10. Thus, irradiation with a laser from the side of the support sheet 10 through the support sheet results in the laser marking on the smooth surface 13b of the film 13 for forming a back surface protective film as illustrated in Fig. 1(b) to Fig. 1(e) and Fig. 4(f) and preventing a blurred letter or symbol marked at the interface between the smooth surface 13b of the film 13 for forming a back surface protective film and the support sheet 10, and thus this allows the clearer laser marking compared to the laser marking on the rough surface 13a.

[0119]

In addition, in the method of manufacturing a third laminate according to the

present embodiment, the support sheet 10 is laminated on the smooth surface 13b of the film 13 for forming a back surface protective film, thus irradiation with a laser from the side of the support sheet 10 through the support sheet after curing the film 13 for forming a back surface protective film to form the back surface protective film 13' results in creation of the laser marking on a smooth surface 13'b of the back surface protective film 13', and this allows the clearer laser marking compared to the laser marking a rough surface 13'a.

[0120]

In an example of a method of manufacturing a semiconductor chip with a back surface protective film known in the art illustrated in Fig. 9, the film 13 for forming a back surface protective film is thermally cured in a state where the smooth surface 13b is exposed in Fig. 9(B). On the other hand, in the method of manufacturing a third laminate according to the present embodiment, the support sheet 10 is laminated on the smooth surface 13b of the film 13 for forming a back surface protective film, and thus the smooth surface 13b is in contact with the support sheet 10 and in a protected state when the film 13 for forming a back surface protective film is cured. Thus, subsequent irradiation with a laser even from the side of the support sheet 10 through the support sheet results in creation of the laser marking on the smooth surface 13'b of the back surface protective film 13', the smooth surface 13'b being in a protected state with the support sheet 10, in the curing, and this allows the clearer laser marking compared to the laser marking on the smooth surface 13'b of the back surface protective film 13' thermally cured in an exposed state.

[0121]

Fig. 3 is a schematic cross-sectional view schematically illustrating another example of an embodiment of a method of manufacturing a third laminate. In Fig. 3 and

figures to follow, the same components as those illustrated in the figures already explained are designated by the same reference signs as in the figures already explained, and their detailed explanations will be omitted.

[0122]

In the present embodiment, the workpiece 14 is a semiconductor device panel composed of an assembly of semiconductor devices including at least one electronic component 62 sealed with a sealing resin layer 64, the semiconductor devices being arranged side by side in a plane. A method of manufacturing a third laminate according to the present embodiment is a method of manufacturing a third laminate 19 including a semiconductor device panel used as a workpiece 14, a film 13 for forming a back surface protective film, and a support sheet 10 laminated in this order, in which

one surface of the semiconductor device panel used as the workpiece 14 is a circuit surface, and another surface of the semiconductor device panel is a back surface 14b (Fig. 3(a'));

one surface of the film 13 for forming a back surface protective film is a smooth surface 13b, and another surface of the film 13 for forming a back surface protective film is a rough surface 13a rougher than the smooth surface 13b; and

the method (Fig. 3(a') to Fig. 3(d')) includes, in an order mentioned below,

(i) attaching the rough surface 13a of the film 13 for forming a back surface protective film to the back surface 14b of the workpiece 14 to face each other (first lamination); and

attaching the support sheet 10 to the smooth surface 13b of the film 13 for forming a back surface protective film (second lamination).

[0123]

In the present embodiment, the semiconductor device panel may be formed by

arranging individual semiconductor devices side by side in a substantially circular region in a plane or may be formed by arranging individual semiconductor devices side by side in a substantially rectangular region in a plane.

[0124]

In the present embodiment illustrated in Fig. 3, as in the embodiment illustrated in Fig. 1, the support sheet 10 is laminated on the smooth surface 13b of the film 13 for forming a back surface protective film, thus irradiation with a laser from the side of the support sheet 10 through the support sheet results in creation of the laser marking on the smooth surface 13b of the film 13 for forming a back surface protective film or the smooth surface 13'b of the back surface protective film 13', and this allows the clearer laser marking compared to the laser marking on the rough surface 13a or the rough surface 13'a. In addition, this is followed by creating a laser marking on the smooth surface 13'b of the back surface protective film 13', the smooth surface 13'b being in a protected state with the support sheet 10, in the curing, and thus irradiation with a laser even from the side of the support sheet 10 through the support sheet allows the clearer laser marking compared to the laser marking on the smooth surface 13'b of the back surface protective film 13' thermally cured in an exposed state.

[0125]

(Method of manufacturing fourth laminate)

A method of manufacturing a fourth laminate according to the present embodiment is a method of manufacturing a fourth laminate 19' including a workpiece 14, a back surface protective film 13', and a support sheet 10 laminated in this order, the method including curing the film 13 for forming a back surface protective film of the third laminate 19 manufactured by the method of manufacturing a third laminate to form the back surface protective film 13'.

[0126]

Fig. 4 is a schematic cross-sectional view schematically illustrating an example of an embodiment of the method of manufacturing a fourth laminate. The method of manufacturing a fourth laminate according to the present embodiment includes:

peeling the tape 17 for protecting a circuit surface from the circuit surface 14a of the workpiece 14 after the second lamination (Fig. 4(e));

creating a laser marking on the film 13 for forming a back surface protective film by irradiating the film 13 for forming a back surface protective film with a laser from the side of the support sheet 10 (Fig. 4(f)); and

curing the film 13 for forming a back surface protective film to form a back surface protective film 13' (Fig. 4(g)). In the present embodiment, a thermosetting film for forming a back surface protective film is used, and in the curing according to the present embodiment, the film is thermally cured under conditions of 130°C for 2 h.

[0127]

The curing conditions for thermally treating and thermally curing the thermosetting film for forming a back surface protective film to form a back surface protective film are not particularly limited as long as the back surface protective film has a degree of curing sufficient to exhibit its function, and are appropriately selected according to the type of the thermosetting film for forming a back surface protective film.

[0128]

For example, the heating temperature during the thermal curing is preferably from 100 to 200°C, more preferably from 110 to 180°C, and particularly preferably from 120 to 170°C. In addition, the heating time during the thermal curing is preferably from 0.5 to 5 hours, more preferably from 0.5 to 3 hours, and particularly preferably from 1 to

2 hours. In the curing, when thermal curing is adopted, the order of the peeling is preferably before the curing in consideration of the heat resistance of the tape 17 for protecting a circuit surface.

[0129]

In the present embodiment illustrated in Fig. 4, as described above, the support sheet 10 has been laminated on the smooth surface 13b of the film 13 for forming a back surface protective film, thus irradiation with a laser from the side of the support sheet 10 through the support sheet results in creation of a laser marking on the smooth surface 13b of the film 13 for forming a back surface protective film, and this allows the clearer laser marking compared to the laser marking on the rough surface 13a.

[0130]

Fig. 5 is a schematic cross-sectional view schematically illustrating another example of an embodiment of the method of manufacturing a fourth laminate. The method of manufacturing a fourth laminate according to the present embodiment includes:

peeling the tape 17 for protecting a circuit surface from the circuit surface 14a of the workpiece 14 after the second lamination (Fig. 5(e));

curing the film 13 for forming a back surface protective film to form a back surface protective film 13' (Fig. 5(f')); and

creating a laser marking on the back surface protective film 13' by irradiating the back surface protective film 13' with a laser from the side of the support sheet 10 (Fig. 5(g')).

[0131]

In the present embodiment illustrated in Fig. 5, as described above, the support sheet 10 has been laminated on the smooth surface 13b of the film 13 for forming a back

surface protective film, thus irradiation with a laser from the side of the support sheet 10 through the support sheet results in creation of a laser marking on the smooth surface 13'b of the back surface protective film 13', and this allows the clearer laser marking compared to the laser marking on the rough surface 13'a. In addition, this results in creation of the laser marking on the smooth surface 13'b of the back surface protective film 13', the smooth surface 13'b being in a protected state with the support sheet 10, in the curing, and thus irradiation with a laser from the side of the support sheet 10 through the support sheet allows the clearer laser marking compared to the laser marking on the smooth surface 13'b of the back surface protective film 13' thermally cured in an exposed state.

[0132]

(Method of manufacturing semiconductor device with back surface protective film)

Fig. 6 is a schematic cross-sectional view schematically illustrating an example of an embodiment of a method of manufacturing a semiconductor device with a back surface protective film. The method of manufacturing a semiconductor device with a back surface protective film according to the present embodiment includes:

dicing the workpiece 14 and the back surface protective film 13' of the fourth laminate 19' manufactured by the method of manufacturing a fourth laminate to form a semiconductor device 21 with a back surface protective film (Fig. 6(h) and Fig. 6(i)); and

picking up the semiconductor device 21 with a back surface protective film from the support sheet 10 (Fig. 6(j)).

[0133]

Fig. 7 is a schematic cross-sectional view schematically illustrating another example of an embodiment of the method of manufacturing a semiconductor device with a back surface protective film. The method of manufacturing a semiconductor device

with a back surface protective film according to the present embodiment includes:

dicing the film 13 for forming a back surface protective film and the workpiece 14 of the third laminate 19 manufactured by the method of manufacturing a third laminate to form a semiconductor device 21' with a film for forming a back surface protective film (Fig. 7(h') and Fig. 7(i'));

picking up the semiconductor device 21' with a film for forming a back surface protective film from the support sheet 10 (Fig. 7(j'));

curing the film 13 for forming a back surface protective film to form a back surface protective film 13' (Fig. 7(k')).

[0134]

Fig. 8 is a schematic cross-sectional view schematically illustrating another example of an embodiment of the method of manufacturing a semiconductor device with a back surface protective film. The method of manufacturing a semiconductor device with a back surface protective film according to the present embodiment includes:

dicing the film 13 for forming a back surface protective film and the workpiece 14 of the third laminate 19 manufactured by the method of manufacturing a third laminate to form a semiconductor device 21' with a film for forming a back surface protective film (Fig. 8(h) and Fig. 8(i));

curing the film 13 for forming a back surface protective film to form a back surface protective film 13'; and

picking up the semiconductor device 21 with a back surface protective film from the support sheet 10 (Fig. 8(j')).

[0135]

In the method of manufacturing a semiconductor device with a back surface protective film according to the present embodiment, the film 13 for forming a back

surface protective film is thermosetting, and in the curing of the film 13 for forming a back surface protective film to form a back surface protective film according to the present embodiment, for example, the film 13 for forming a back surface protective film is thermally cured under conditions of 130°C for 2 h.

[0136]

The curing conditions for thermally curing the thermosetting film for forming a back surface protective film to form a back surface protective film are not particularly limited as long as the back surface protective film has a degree of curing sufficient to exhibit its function as described above and are appropriately selected according to the type of the thermosetting film for forming a back surface protective film.

[0137]

In the method of manufacturing a semiconductor device with a back surface protective film according to the present embodiment, the film 13 for forming a back surface protective film is energy ray-curable, and the curing of the film 13 for forming a back surface protective film to form a back surface protective film may include irradiating the film 13 for forming a back surface protective film with an energy ray to cure the film 13 for forming a back surface protective film with an energy ray.

[0138]

The curing conditions for curing the energy ray-curable film for forming a back surface protective film with an energy ray to form the protective film are not particularly limited as long as the protective film has a degree of curing sufficient to exhibit its function, and are appropriately selected according to the type of the energy ray-curable film for forming a back surface protective film.

For example, the illuminance of the energy ray during the energy ray curing of the energy ray-curable film for forming a back surface protective film is preferably from

4 to 280 mW/cm². In addition, the dose of the energy ray during the curing is preferably from 3 to 1000 mJ/cm².

[0139]

For the energy ray-curable film for forming a back surface protective film, a film disclosed, for example, in WO 2017/188200 or WO 2017/188218 can be also used.

[Examples]

[0140]

Hereinafter, the present invention will be described in further detail with reference to specific examples. However, the present invention is in no way limited to the examples described below.

[0141]

(Example 1)

The following components were mixed each at a blending ratio (in terms of solid content) shown in Table 1, diluted with methyl ethyl ketone to make the solid content concentration be 50 mass% relative to a total mass of a protective film-forming composition, and a protective film-forming composition for forming a film for forming a back surface protective film was prepared.

(A-1): Binder polymer: (meth)acrylic ester copolymer formed by copolymerizing 55 parts by mass of n-butyl acrylate, 10 parts by mass of methyl acrylate, 20 parts by mass of glycidyl methacrylate, and 15 parts by mass of 2-hydroxyethyl acrylate (weight average molecular weight: 800000, glass transition temperature: -28°C)

(B-1) Bisphenol A-type epoxy resin (jER828 available from Mitsubishi Chemical Corporation, an epoxy equivalent of 184 to 194 g/eq)

(B-2) Bisphenol A-type epoxy resin (jER1055 available from Mitsubishi Chemical Corporation, an epoxy equivalent of 800 to 900 g/eq)

(B-3) Dicyclopentadiene-type epoxy resin (Epiclon HP-7200HH available from DIC Corporation, an epoxy equivalent of 255 to 260 g/eq)

(B-4) Cresol novolac-type epoxy resin (EOCN-104 available from Nippon Kayaku Co., Ltd., an epoxy equivalent of 220 g/eq)

(C-1) Thermally activated latent epoxy resin curing agent: dicyandiamide (ADEKA Hardener EH-3636AS available from ADEKA Corporation, an active hydrogen content of 21 g/eq)

(D-1) Curing accelerator: 2-phenyl-4,5-dihydroxymethylimidazole (Curezol 2PHZ available from Shikoku Chemicals Corporation)

(E-1) Amorphous silica filler (SV-10 available from Tatsumori Ltd., an average particle size of 8 μm)

(F-1) Silane coupling agent: γ -glycidoxypyltrimethoxysilane (KBM403 available from Shin-Etsu Chemical Co., Ltd., methoxy equivalent: 12.7 mmol/g, molecular weight: 236.3)

(G-1) Colorant: a pigment obtained by mixing 32 parts by mass of phthalocyanine blue pigment (Pigment Blue 15:3), 18 parts by mass of isoindolinone yellow pigment (Pigment Yellow 139), and 50 parts by mass of anthraquinone red pigment (Pigment Red 177) and making the ratio of the total amount of these three pigments to an amount of a styrene acrylic resin be 1/3 (mass ratio) to form a pigment. [0142]

(Formation of film for forming back surface protective film)

A release treated surface (surface roughness Ra: 30 nm) of a release film ("SP-PET501031" available from Lintec Corporation, a thickness of 50 μm , corresponding to the second release film) formed by subjecting one side of a film made of polyethylene terephthalate (PET) to release treatment by silicone treatment was coated with the

composition (III-1) obtained above and dried at 100°C for 3 minutes, and a film for forming a back surface protective film having a thickness of 25 µm was formed.

Furthermore, a release treated surface (surface roughness Ra: 30 nm) of a release film (“SP-PET381031” available from Lintec Corporation, a thickness of 38 µm, corresponding to the first release film) formed by subjecting one side of a film made of polyethylene terephthalate (PET) to release treatment by silicone treatment was separately bonded to the exposed surface (the surface opposite to the side provided with the release film) of the film for forming a back surface protective film, from the first release film side, with a laminate roll under conditions of temperature of $23 \pm 5^{\circ}\text{C}$, pressure of 0.4 MPa, and speed of 1 m/min, and a laminated sheet with release films laminated on both sides of the film for forming a back surface protective film (i.e., a first laminate) was produced.

[0143]

(Evaluation of occurrence frequency of release failure)

Ten A4 size laminated sheets of the second release film/the film for forming a back surface protective film/the first release film were produced.

The first release film was peeled from a short side of the A4 size laminated sheet.

Of the 10 laminated sheets, the number of sheets in which release failure occurred when the first release film was peeled from a short side of the A4 size sheet was determined based on the following criteria to evaluate the occurrence frequency of release failure.

[0144]

- Release failure occurred in 0 to 1 sheet ... A: excellent.
- Release failure occurred in 2 to 3 sheets ... B: good.

- Release failure occurred in 4 to 5 sheets ... C: average.
- Release failure occurred in 6 to 10 sheets ... D: poor.

[0145]

(Measurement of surface roughness (Ra))

The surface roughness (Ra) of the surface of the measurement object was measured at 10 points in the plane using a light interference surface metrology measuring apparatus (product name “WYKO WT1100” available from Veeco Metrology Group) in PSI mode at a magnification of 10 times, and the first decimal place of the average value was rounded off to obtain an integer value.

The surface roughness (Ra) on the side of the workpiece of the uncured film for forming a back surface protective film was measured when the first release film was peeled from the laminated sheet of the second release film/the film for forming a back surface protective film/the first release film, and the surface roughness (Ra) on the side of the support sheet of the film for forming a back surface protective film was measured when the second release film was peeled.

[0146]

(Manufacture of support sheet)

A release treated surface of the release film (“SP-PET381031” available from Lintec Corporation, a thickness of 38 μm) was coated with a pressure sensitive adhesive composition and dried at 100°C for 3 minutes to form an ultraviolet light-curable pressure sensitive adhesive layer (a thickness after drying of 10 μm). A polypropylene film (a thickness of 80 μm , available from Gunze Limited) used as the substrate was separately bonded to the exposed surface (the surface opposite to the side provided with the release film), and a support sheet was obtained.

[0147]

The adhesive composition contained 100 parts by mass (solid content) of a (meth)acrylic alkyl ester copolymer, 6.6 parts by mass (solid content) of a trifunctional xylylene diisocyanate crosslinking agent (“Takenate D110N” available from Mitsui Takeda Chemicals, Inc.), and 3.0 parts by mass (solid content) of a photopolymerization initiator (“Irgacure 127” available from BASF), in which the solid content concentration was adjusted to 30 mass% using a mixed solvent of methyl ethyl ketone, toluene, and ethyl acetate. In addition, the (meth)acrylic alkyl ester copolymer was an ultraviolet-curable acrylic copolymer with a weight average molecular weight of 700000 obtained by reacting 70 parts by mass of 2-ethylhexyl acrylate (which may be hereinafter abbreviated as “2EHA”), 10 parts by mass of vinyl acetate (which may be hereinafter abbreviated as “VAc”), and 20 parts by mass of 2-hydroxyethyl acrylate (which may be hereinafter abbreviated as “HEA”) to produce a precopolymer, and then further reacting 21.4 parts by mass of 2-methacryloyloxyethyl isocyanate (2-isocyanatoethyl methacrylate, which may be hereinafter abbreviated as “MOI”) (an amount in which the total number of moles of isocyanate groups in MOI is 0.8 times the total number of moles of hydroxyl groups in HEA) with the precopolymer.

[0148]

(Workpiece)

A 12-inch silicon wafer (a thickness of 100 μm) having a #2000 polished surface was used as the workpiece.

[0149]

(Manufacture of third laminate)

For the manufacture of a third laminate, a mechanism for peeling the first release film, a mechanism for attaching the film for forming a back surface protective film, a mechanism for peeling the second release film, and a mechanism for attaching the

support sheet were connected in a single apparatus, and between the mechanisms, a second laminate including the film for forming a back surface protective film attached to the silicon wafer used as the workpiece was transferred one by one using a transfer arm.

[0150]

First, from the laminated sheet composed of the second release film/the film for forming a back surface protective film/the first release film (i.e., the first laminate), the film for forming a back surface protective film and the first release film were punched into a shape of the silicon wafer used as the workpiece, and the first release film was peeled. The second release film/the film for forming a back surface protective film was attached to the #2000 polished surface of the silicon wafer under conditions of temperature of 23°C and pressure of 0.5 MPa.

Then, the second release film was peeled from the laminate composed of the second release film/the film for forming a back surface protective film/the silicon wafer, and a second laminate including the film for forming a back surface protective film attached to the silicon wafer used as the workpiece was obtained.

[0151]

Furthermore, the release film of the support sheet was peeled, and the exposed surface of the pressure sensitive adhesive layer of the support sheet and the exposed surface of the film for forming a back surface protective film were bonded using a wafer mounter included in the same apparatus under attaching conditions of attaching speed of 20 mm/s and pressing pressure of 0.3 MPa, and a third laminate composed of the support sheet, the film for forming a back surface protective film, and the semiconductor wafer laminated in this order was obtained.

[0152]

The transfer time of the workpiece from the attaching starting time of the first

lamination in which the film for forming a back surface protective film was attached to the silicon wafer to the attaching completion time of the second lamination in which the support sheet was attached to the film for forming a back surface protective film was 60 s.

[0153]

The transfer distance of the workpiece from the attaching starting point of the first lamination in which the film for forming a back surface protective film was attached to the silicon wafer to the attaching completion point of the second lamination in which the support sheet was attached to the film for forming a back surface protective film was 2900 mm.

[0154]

(Thermal curing)

The third laminate was thermally treated under conditions of 130°C for 2 h, and a fourth laminate composed of the support sheet, the back surface protective film, and the silicon wafer laminated in this order was obtained.

[0155]

(Evaluation of laser marking)

The fourth laminate was marked by irradiating the surface of the back surface protective film in the fourth laminate, the surface on the pressure sensitive adhesive layer side, with laser light through the support sheet using a laser marking apparatus (“CSM300M” available from EO Technics). At this time, a letter with a size of 0.3 mm x 0.2 mm was marked.

[0156]

Then, the mark (laser marking) of the back surface protective film was visually observed via the support sheet, and the visibility of the marking (letter) was evaluated

according to the following criteria. The results are shown in Table 1.

Good: The marking was clear and easily visible.

Poor: The marking was unclear and invisible.

[0157]

[Table 1]

			Example 1	Example 2	Example 3	Example 4
Components contained in composition of protective film-forming composition (content (parts by mass))	Binder polymer (A)	A-1	20.0			
	Thermosetting resin (B)	B-1	13.0			
		B-2	1.0			
		B-3	1.0			
		B-4	1.0			
	Thermosetting agent (C)	C-1	0.5			
	Curing accelerator (D)	D-1	0.5			
	Filler (E)	E-1	60			
	Silane coupling agent (F)	F-1	1.0			
	Colorant (G)	G-1	2.0			
Temperature and pressure conditions when first release film was bonded to film for forming back surface protective film			23°C 0.4 MPa	40°C 0.5 MPa	50°C 0.5 MPa	60°C 0.5 MPa
Number of sheets in which release failure			0/10	0/10	0/10	0/10

occurred/10				
Evaluation of occurrence frequency of release failure	A	A	A	A
Surface roughness (nm) on side of workpiece of film for forming back surface protective film	640	372	253	158
Surface roughness (nm) on side of support sheet of film for forming back surface protective film	30	30	30	30
Surface roughness on side of workpiece of film for forming back surface protective film/surface roughness on side of support sheet of film for forming back surface protective film	21.33	12.40	8.43	5.27
Evaluation of laser marking	Good	Good	Good	Good

[0158]

(Example 2)

The number of sheets in which release failure occurred was examined to evaluate the occurrence frequency of release failure, and the surface roughness (Ra) was measured in the same manner as in Example 1 except for changing the conditions for bonding the first release film to the exposed surface of the film for forming a back surface protective film in production of the laminated sheet of the second release film/the film for forming a back surface protective film/the first release film (i.e., the first laminate) in Example 1 to conditions of temperature of 40°C, pressure of 0.5 MPa, and speed of 1 m/min.

In addition, the second laminate, the third laminate, and the fourth laminate were manufactured in the same manner as in Example 1, and the laser marking was evaluated. The results are shown in Table 1.

[0159]

(Example 3)

The number of sheets in which release failure occurred was examined to evaluate the occurrence frequency of release failure, and the surface roughness (Ra) was measured in the same manner as in Example 1 except for changing the conditions for bonding the first release film to the exposed surface of the film for forming a back surface protective film in production of the laminated sheet of the second release film/the film for forming a back surface protective film/the first release film (i.e., the first laminate) in Example 1 to conditions of temperature of 50°C, pressure of 0.5 MPa, and speed of 1 m/min.

In addition, the second laminate, the third laminate, and the fourth laminate were manufactured in the same manner as in Example 1, and the laser marking was evaluated. The results are shown in Table 1.

[0160]

(Example 4)

The number of sheets in which release failure occurred was examined to evaluate the occurrence frequency of release failure, and the surface roughness (Ra) was measured in the same manner as in Example 1 except for changing the conditions for bonding the first release film to the exposed surface of the film for forming a back surface protective film in production of the laminated sheet of the second release film/the film for forming a back surface protective film/the first release film (i.e., the first laminate) in Example 1 to conditions of temperature of 60°C, pressure of 0.5 MPa, and speed of 1 m/min.

In addition, the second laminate, the third laminate, and the fourth laminate were manufactured in the same manner as in Example 1, and the laser marking was evaluated.

The results are shown in Table 1.

[0161]

(Example 5)

The number of sheets in which release failure occurred was examined to evaluate the occurrence frequency of release failure, and the surface roughness (Ra) was measured in the same manner as in Example 1 except for changing the conditions for bonding the first release film to the exposed surface of the film for forming a back surface protective film in production of the laminated sheet of the second release film/the film for forming a back surface protective film/the first release film (i.e., the first laminate) in Example 1 to conditions of temperature of 70°C, pressure of 0.5 MPa, and speed of 1 m/min.

In addition, the second laminate, the third laminate, and the fourth laminate were manufactured in the same manner as in Example 1, and the laser marking was evaluated. The results are shown in Table 2.

[0162]

(Example 6)

The number of sheets in which release failure occurred was examined to evaluate the occurrence frequency of release failure, and the surface roughness (Ra) was measured in the same manner as in Example 1 except for changing the conditions for bonding the first release film to the exposed surface of the film for forming a back surface protective film in production of the laminated sheet of the second release film/the film for forming a back surface protective film/the first release film (i.e., the first laminate) in Example 1 to conditions of temperature of 70°C, pressure of 0.7 MPa, and speed of 1 m/min.

In addition, the second laminate, the third laminate, and the fourth laminate were

manufactured in the same manner as in Example 1, and the laser marking was evaluated. The results are shown in Table 2.

[0163]

(Example 7)

The number of sheets in which release failure occurred was examined to evaluate the occurrence frequency of release failure, and the surface roughness (Ra) was measured in the same manner as in Example 1 except for changing the conditions for bonding the first release film to the exposed surface of the film for forming a back surface protective film in production of the laminated sheet of the second release film/the film for forming a back surface protective film/the first release film (i.e., the first laminate) in Example 1 to conditions of temperature of 70°C, pressure of 0.8 MPa, and speed of 1 m/min.

In addition, the second laminate, the third laminate, and the fourth laminate were manufactured in the same manner as in Example 1, and the laser marking was evaluated. The results are shown in Table 2.

[0164]

(Example 8)

The number of sheets in which release failure occurred was examined to evaluate the occurrence frequency of release failure, and the surface roughness (Ra) was measured in the same manner as in Example 1 except for changing the conditions for bonding the first release film to the exposed surface of the film for forming a back surface protective film in production of the laminated sheet of the second release film/the film for forming a back surface protective film/the first release film (i.e., the first laminate) in Example 1 to conditions of temperature of 70°C, pressure of 0.9 MPa, and speed of 1 m/min.

In addition, the second laminate, the third laminate, and the fourth laminate were manufactured in the same manner as in Example 1, and the laser marking was evaluated. The results are shown in Table 2.

[0165]

(Comparative Example 1)

(Formation of film for forming back surface protective film)

A release treated surface (surface roughness Ra: 218 nm) of a release film (U4Z-50 available from Teijin DuPont Films Co., Ltd., thickness: 50 μm , corresponding to the second release film) formed by subjecting one side of a film made of polyethylene terephthalate (PET) to release treatment by silicone treatment was coated with the composition (III-1) obtained above and dried at 100°C for 3 minutes, and a film for forming a back surface protective film having a thickness of 25 μm was formed.

Furthermore, a release treated surface (surface roughness: 30 nm) of the release film ("SP-PET381031" available from Lintec Corporation, a thickness of 38 μm , corresponding to the first release film) formed by subjecting one side of a film made of polyethylene terephthalate (PET) to release treatment by silicone treatment was separately bonded from the first release film side to the exposed surface (the surface opposite to the side provided with the release film) of the film for forming a back surface protective film with a laminate roll under conditions of temperature of 70°C, pressure of 0.9 MPa, and speed of 1 m/min, and a laminated sheet with release films laminated on both sides of the film for forming a back surface protective film (i.e., a first laminate) was produced.

The number of sheets in which release failure occurred was examined to evaluate the occurrence frequency of release failure, and the surface roughness (Ra) was measured in the same manner as in Example 1.

In addition, the second laminate, the third laminate, and the fourth laminate were manufactured in the same manner as in Example 1, and the laser marking was evaluated.

The results are shown in Table 2.

[0166]

[Table 2]

			Example 5	Example 6	Example 7	Example 8	Comparative Example 1
Components contained in composition of protective film- forming composition (content (parts by mass))	Binder polymer (A)	A-1	20.0				
	Thermosetting resin (B)	B-1	13.0				
		B-2	1.0				
		B-3	1.0				
		B-4	1.0				
	Thermosetting agent (C)	C-1	0.5				
	Curing accelerator (D)	D-1	0.5				
	Filler (E)	E-1	60				
	Silane coupling agent (F)	F-1	1.0				
	Colorant (G)	G-1	2.0				
Temperature and pressure conditions when first release film was bonded to film for forming back surface			70°C 0.5 MPa	70°C 0.7 MPa	70°C 0.8 MPa	70°C 0.9 MPa	70°C 0.9 MPa

protective film					
Number of sheets in which release failure occurred/10	2/10	3/10	5/10	7/10	8/10
Evaluation of occurrence frequency of release failure	B	B	C	D	D
Surface roughness (nm) on side of workpiece of film for forming back surface protective film	88	49	38	34	30
Surface roughness (nm) on side of support sheet of film for forming back surface protective film	29	29	29	29	218
Surface roughness on side of workpiece of film for forming back surface protective film/surface roughness on side of support sheet of film for forming back surface protective film	3.03	1.69	1.31	1.17	0.14
Evaluation of laser marking	Good	Good	Good	Good	Poor

[Industrial Applicability]

[0167]

The method of manufacturing a third laminate and the method of manufacturing a fourth laminate according to the present invention can be used for manufacturing a semiconductor device with a back surface protective film.

[Reference Signs List]

[0168]

- 1 Composite sheet for forming protective film
- 5 First laminate
- 6 Second laminate
- 7 Semiconductor chip with back surface protective film
- 8 Semiconductor wafer
- 8b Back surface of semiconductor wafer
- 9 Semiconductor chip
- 10 Support sheet
- 11 Substrate
- 12 Pressure sensitive adhesive layer
- 13 Film for forming back surface protective film
- 13' Back surface protective film
- 13a Rough surface of film for forming back surface protective film
- 13b Smooth surface of film for forming back surface protective film
- 14 Workpiece
- 14a Circuit surface of workpiece
- 14b Back surface of workpiece
- 151 First release film
- 152 Second release film
- 16 Adhesive layer for jig
- 17 Tape for protecting circuit surface
- 18 Fixing jig
- 19 Third laminate
- 19' Fourth laminate
- 20 Semiconductor device

- 21 Semiconductor device with back surface protective film
- 21' Semiconductor device with film for forming back surface protective film
- 62 Electronic component
- 63 Circuit substrate
- 63a Terminal-forming surface
- 64 Sealing resin layer

[CLAIMS]

[Claim 1]

A method of manufacturing a third laminate, the third laminate comprising a workpiece, a film for forming a back surface protective film, and a support sheet laminated in this order, wherein

one surface of the workpiece is a circuit surface, and another surface of the workpiece is a back surface;

one surface of the film for forming a back surface protective film is a smooth surface, and another surface of the film for forming a back surface protective film is a rough surface rougher than the smooth surface; and

the method comprises, performed in this order,

(i) attaching the rough surface of the film for forming a back surface protective film, face-to-face, to the back surface of the workpiece (first lamination); and

(ii) attaching the support sheet to the smooth surface of the film for forming a back surface protective film (second lamination).

[Claim 2]

The method of manufacturing a third laminate according to claim 1, wherein at least a process from the first lamination to the second lamination is performed with an apparatus for attaching the film for forming a back surface protective film and an apparatus for attaching the support sheet being connected to each other or performed in the same apparatus.

[Claim 3]

The method of manufacturing a third laminate according to claim 1 or 2, wherein a second laminate including the film for forming a back surface protective film attached to the workpiece is transferred one by one from the first lamination to the

second lamination.

[Claim 4]

The method of manufacturing a third laminate according to any one of claims 1 to 3, wherein a transfer distance of the workpiece from an attaching starting point of the first lamination to an attaching completion point of the second lamination is 7000 mm or shorter.

[Claim 5]

The method of manufacturing a third laminate according to any one of claims 1 to 4, wherein a transfer time of the workpiece from an attaching starting time of the first lamination to an attaching completion time of the second lamination is 150 s or shorter.

[Claim 6]

The method of manufacturing a third laminate according to any one of claims 1 to 5, wherein

the circuit surface of the workpiece is protected with a tape for protecting a circuit surface; and

the method comprises peeling off the tape for protecting a circuit surface from the circuit surface of the workpiece after the second lamination.

[Claim 7]

The method of manufacturing a third laminate according to claim 6, wherein the back surface of the workpiece is a ground surface, and the tape for protecting a circuit surface is a tape for grinding a back surface.

[Claim 8]

The method of manufacturing a third laminate according to any one of claims 1 to 7, wherein the workpiece is a semiconductor wafer.

[Claim 9]

The method of manufacturing a third laminate according to any one of claims 1 to 7, wherein the workpiece is a semiconductor device panel including an assembly of semiconductor devices in which at least one electronic component is sealed with a sealing resin.

[Claim 10]

The method of manufacturing a third laminate according to any one of claims 1 to 9, wherein

the support sheet is provided with a pressure sensitive adhesive layer on a substrate; and

the method further comprises attaching the pressure sensitive adhesive layer of the support sheet to the smooth surface of the film for forming a back surface protective film (second lamination).

[Claim 11]

The method of manufacturing a third laminate according to claim 10, wherein the pressure sensitive adhesive layer is energy ray-curable.

[Claim 12]

The method of manufacturing a third laminate according to any one of claims 1 to 11, the method comprising creating a laser marking on the film for forming a back surface protective film by irradiating the film for forming a back surface protective film with a laser from the side of the support sheet.

[Claim 13]

A method of manufacturing a fourth laminate, the fourth laminate comprising a workpiece, a back surface protective film, and a support sheet laminated in this order, the method comprising:

forming the back surface protective film by curing the film for forming a back

surface protective film of the third laminate manufactured by the manufacturing method described in any one of claims 1 to 12.

[Claim 14]

The method of manufacturing a fourth laminate according to claim 13, the method comprising creating a laser marking on the back surface protective film by irradiating the back surface protective film with a laser from the side of the support sheet.

[Claim 15]

A method of manufacturing a semiconductor device with a back surface protective film, the method comprising:

dicing the workpiece and the back surface protective film of the fourth laminate manufactured by the manufacturing method described in claim 13 or 14 to form a semiconductor device with a back surface protective film; and

picking up the semiconductor device with a back surface protective film from the support sheet.

[Claim 16]

A method of manufacturing a semiconductor device with a back surface protective film, the method comprising:

dicing the film for forming a back surface protective film and the workpiece of the third laminate manufactured by the manufacturing method described in any one of claims 1 to 12 to form a semiconductor device with a film for forming a back surface protective film;

forming a back surface protective film by curing the film for forming a back surface protective film; and

picking up the semiconductor device with a film for forming a back surface protective film or a semiconductor device with a back surface protective film from the

support sheet.

[Claim 17]

The method of manufacturing a semiconductor device with a back surface protective film according to claim 15 or 16, wherein the film for forming a back surface protective film is thermosetting; and the forming a back surface protective film includes thermally treating the film for forming a back surface protective film to thermally cure the film for forming a back surface protective film.

[Claim 18]

The method of manufacturing a semiconductor device with a back surface protective film according to claim 15 or 16, wherein the film for forming a back surface protective film is energy ray-curable; and the forming a back surface protective film includes irradiating the film for forming a back surface protective film with an energy ray to cure the film for forming a back surface protective film with an energy ray.

[Claim 19]

A third laminate comprising a workpiece, a film for forming a back surface protective film, and a support sheet laminated in this order, wherein

one surface of the workpiece is a circuit surface, and another surface of the workpiece is a back surface;

one surface of the film for forming a back surface protective film is a smooth surface, and another surface of the film for forming a back surface protective film is a rough surface rougher than the smooth surface;

the rough surface of the film for forming a back surface protective film is bonded to the back surface of the workpiece; and

the support sheet is bonded to the smooth surface of the film for forming a back surface protective film.