

DESCRIPTION

Title of Invention

FIRST PROTECTIVE FILM FORMING SHEET

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Technical Field

[0001]

The present invention relates to a first protective film forming sheet.

Priority is claimed on Japanese Patent Application No. 2016-197523, filed on

10 October 5, 2016, the amount of which is incorporated herein by reference.

Background Art

[0002]

In the related art, in a case in which a multi-pin LSI package, which is used in

15 MPU or a gate array, is mounted on a printed wiring board, a flip chip mounting method in which a semiconductor chip in which convex electrodes (hereinafter, referred to as “bump” in this specification) made of eutectic solder, high-temperature solder, metal, or the like are formed in connection pad portions is used, and these bumps are made to face, brought into contact with, and melting/diffusion-joined to the corresponding terminal

20 portions on a chip mounting substrate using a so-called face down method has been employed.

[0003]

The semiconductor chip that is used in this mounting method is obtained by, for example, dividing a semiconductor wafer having bumps formed on a circuit surface (that

25 is, a bump-formed surface) by grinding a surface opposite to the circuit surface or dicing

the semiconductor wafer. In the process of obtaining the above-described semiconductor chip, generally, for the purpose of protecting the bump-formed surface and a bump of the semiconductor wafer, a curable resin film is attached to a bump-formed surface, and this film is cured so as to form a protective film on the bump-formed surface.

[0004]

On the other hand, the semiconductor device is expected to have higher functions, and the semiconductor chip tends to be enlarged in size. However, regarding the semiconductor chip which is enlarged in size, the bumps are likely to be deformed due to the occurrence of warpage in a state in which the semiconductor chip is mounted on the substrate, and in particular, cracks are likely to occur in the bump located at the end portion of the semiconductor chip or in the vicinity thereof. The protective film formed on the bump-formed surface is also expected to limit such breakage of the bump.

[0005]

A method of forming a protective film on the bump-formed surface of the semiconductor wafer will be described with reference to FIG. 6.

For forming the protective film, a protective film forming sheet 8 as shown in FIG. 6(a) is used. The protective film forming sheet 8 is formed by stacking a buffer layer 83 and a curable resin film 82 on a base member 81 in this order. The buffer layer 83 has a buffer action against the force applied to the buffer layer 83 and the layer adjacent thereto.

[0006]

First, the protective film forming sheet 8 is disposed so that the curable resin film 82 faces the bump-formed surface 9a of the semiconductor wafer 9.

Then, the protective film forming sheet 8 is crimped to the semiconductor wafer

9, and as shown in FIG. 6(b), the curable resin film 82 of the protective film forming sheet 8 is attached to the bump-formed surface 9a of the semiconductor wafer 9. At this time, the curable resin film 82 is attached while heating the curable resin film 82. As a result, the curable resin film 82 adheres to the bump-formed surface 9a of the semiconductor wafer 9 and a front surface 91a of the bump 91, but when the bump 91 penetrates the curable resin film 82, the buffer layer 83 is also brought into close contact a portion of the front surface 91a of the bump 91.

After attaching the curable resin film 82, the surface (back surface) 9b on the side opposite to the bump-formed surface 9a of the semiconductor wafer 9 is further ground, if necessary, and then, on the back surface 9b of the semiconductor wafer 9, separately, a protective film forming sheet for protecting the back surface 9b is attached (not shown).

[0007]

Then, as shown in FIG. 6(c), the base member 81 and the buffer layer 83 are peeled from the curable resin film 82.

Then, a protective film 82' is formed by curing the curable resin film 82 as described above FIG. 6(d).

[0008]

In such a method of forming the protective film, it is necessary that the upper portion 910 of the bump 91 penetrates and protrudes through the protective film 82'.

For this, it is important that at a stage where the base member 81 and the buffer layer 83 are peeled, the upper portion 910 of the bump 91 penetrates and protrudes through the curable resin film 82 and curable resin film 82 does not remain on the upper portion 910 of the bump 91. On the contrary, FIG. 7 shows an example of a state in which the

curable resin film 82 remains on the upper portion 910 of the bump 91. Here, an

example in which the entire surface of the front surface 91a of the bump 91 is covered with the curable resin film 82 is described, but this is an example of the state where the curable resin film 82 remains. For example, in upper portion 910 of the bump 91, a portion of the front surface 91a is exposed without being covered with the curable resin film 82 in some cases.

[0009]

As described above, as a protective film forming sheet capable of forming a protective film without the curable resin film residual on the upper portion of the bump, those in which an elastic ratio between a storage shear modulus of a curable resin film and a storage shear modulus of the buffer layer at a temperature at which a sheet is attached to a semiconductor wafer is specified within a specific range (refer to Patent Document 1), and those in which a melt viscosity of a curable resin film at a temperature at which a sheet is attached to a semiconductor wafer is specified within a specific range (refer to Patent Document 2) are disclosed.

[0010]

Both of the protective film forming sheets disclosed in Patent Documents 1 and 2 define the physical properties of the curable resin film at the temperature when these sheets are attached to the semiconductor wafer. However, the buffer layer and the curable resin film constituting these sheets are greatly different in the degree of distortion between an initial stage of attaching to the semiconductor wafer and a stage after a middle stage. This is also apparent from FIG. 6(a) and FIG. 6(b). If the degree of distortion is different as described above, the physical properties of a portion of the buffer layer and the curable resin film change greatly. The inventors of the present invention have paid attention to this point and conducted examination. As a result of examination, it has been found that in the attachment stages, particularly in a stage after

the middle stage of attachment, where the upper portion of the bump tries to penetrate and protrude through the curable resin film, it is important to appropriately adjust the properties of the curable resin film and the like in order to limit the residual of the curable resin film on the upper portion of the bump. On the other hand, none of the protective film forming sheets disclosed in Patent Documents 1 and 2 is configured in consideration of such a point, and the effect of limiting the residual of the curable resin film on the upper portion of the bump may be insufficient.

Citation List

110 Patent Literature

[0011]

[Patent Document 1] Japanese Unexamined Patent Application, First

Publication No. 2015-206006

[Patent Document 2] Japanese Patent No. 5666335

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Summary of Invention

Technical Problem

[0012]

An object of the present invention is to provide a new protective film forming sheet which is provided with a curable resin film for forming a protective film on a surface by attaching the curable resin film to the surface of a semiconductor wafer, which has a bump and curing the curable resin film, and is capable of limiting the residual of the curable resin film on the upper portion of the bump when the curable resin film is attached to the surface.

125

Solution to Problem

[0013]

According to the present invention, there is provided a first protective film forming sheet including a first base member; a buffer layer formed on the first base member; and a curable resin film formed on the buffer layer, in which the curable resin film is attached to a surface of a semiconductor wafer, which has a bump, and cured so as to form a first protective film on the surface, at the time of performing a distortion dispersion measurement in which a shear modulus G' of a test piece of the buffer layer is measured by causing a distortion to occur on the test piece of the buffer layer having a diameter of 8 mm and a thickness of 1 mm under conditions of a temperature of 90°C and a frequency of 1 Hz, the shear modulus of the test piece of buffer layer is G_{b300}' when the distortion of the test piece of the buffer layer is 300%, at the time of performing a distortion dispersion measurement in which a shear modulus G' of the test piece of the curable resin film is measured by causing a distortion to occur on the test piece of the curable resin film having a diameter of 8 mm and a thickness of 1 mm under conditions of a temperature of 90°C and a frequency of 1 Hz, the shear modulus of the test piece of the curable resin film is G_{c300}' when the distortion of the test piece of the curable resin film is 300%, and the G_{b300}' and the G_{c300}' satisfy a relationship represented by Expression (w1): $G_{b300}' \geq G_{c300}'$.

[0014]

In the first protective film forming sheet of the present invention, a shear modulus G_{b200}' of the test piece of the buffer layer when the distortion of the test piece of the buffer layer is 200%, and a shear modulus G_{c200}' of the test piece of the curable resin film when the distortion of the test piece of the curable resin film is 200% may satisfy a relationship represented by Expression (w2): $G_{b200}' \geq G_{c200}'$.

[0015]

In the first protective film forming sheet of the present invention, a shear modulus G_{b400}' of the test piece of the buffer layer when the distortion of the test piece of the buffer layer is 400%, and a shear modulus G_{c400}' of the test piece of the curable resin film when the distortion of the test piece of the curable resin film is 400% may satisfy a relationship represented by Expression (w3): $G_{b400}' \geq G_{c400}'$.

[0016]

In the first protective film forming sheet of the present invention, in a function of the distortion of the test piece of the buffer layer and the shear modulus G_b' of the test piece of the buffer layer which are obtained by the distortion dispersion measurement, a region where the shear modulus G_b' is not constant may exist, and the shear modulus G_b' when the distortion of the test piece of the buffer layer is 300% may be included in the region.

In the first protective film forming sheet of the present invention, in a function of the distortion of the test piece of the curable resin film and a shear modulus G_c' of the test piece of the curable resin film which are obtained by the distortion dispersion measurement, a region where the shear modulus G_c' is not constant may exist, and the shear modulus G_c' when the distortion of the test piece of the curable resin film is 300% may be included in the region.

In the first protective film forming sheet of the present invention, the curable resin film may contain a resin component, the amount of the filler of the curable resin film may be 45% by mass or less, and a weight-average molecular weight of the resin component may be 30,000 or less.

Advantageous Effects of Invention

[0017]

The first protective film can be formed on the surface by attaching the first protective film forming sheet of the present invention on the surface of the semiconductor wafer, which has the bump and curing the curable resin film. When the curable resin film is attached to the surface, it is possible to limit residual of the curable resin film on the upper portion of the bump.

Brief Description of Drawings

[0018]

FIG. 1 is a cross-sectional view schematically showing an embodiment of a first protective film forming sheet of the present invention.

FIG. 2 is a cross-sectional view schematically showing another embodiment of the first protective film forming sheet of the present invention.

FIG. 3 is a cross-sectional view schematically showing an example of a method of using the first protective film forming sheet as shown in FIG. 1.

FIG. 4 is a cross-sectional view schematically showing an example of a method of using the first protective film forming sheet as shown in FIG. 2.

FIG. 5 is a graph showing measurement results of shear modulus G' of a test piece of a buffer layer and a thermosetting resin film of examples and comparative examples.

FIG. 6 is a cross-sectional view schematically showing a method of forming a protective film on a bump-formed surface of a semiconductor wafer.

FIG. 7 is a cross-sectional view schematically showing an example of a state in which a curable resin film remains on an upper portion of a bump.

Description of Embodiments

[0019]

◇ First Protective Film Forming Sheet

A first protective film forming sheet of the present invention includes a first base member, a buffer layer formed on the first base member, and a curable resin film formed on the buffer layer.

The curable resin film is attached to a surface of a semiconductor wafer, which has a bump and is cured so as to form a first protective film on the surface.

In addition, the first protective film forming sheet of the present invention satisfies a relationship represented by Expression (w1).

$$G_{b300'} \geq G_{c300'} \quad (w1)$$

[0020]

Here, $G_{b300'}$ is a shear modulus of a test piece of the buffer layer when a distortion of the test piece of the buffer layer is 300% at the time of performing a distortion dispersion measurement on the test piece of the buffer layer. At this time, the distortion dispersion measurement is performed by causing the distortion to occur on the test piece of the buffer layer having a diameter of 8 mm and a thickness of 1 mm under the conditions of a temperature of 90°C and a frequency of 1 Hz and measuring the shear modulus G' of the test piece of the buffer layer.

Further, $G_{c300'}$ is the shear modulus of the test piece of the curable resin film when the distortion of the test piece of the curable resin film is 300% at the time of performing the distortion dispersion measurement is performed on the test piece of the curable resin film. The distortion dispersion measurement in this case is performed by using the same method as that used in a case of the test piece of the buffer layer. That is, the distortion dispersion measurement is performed by causing the distortion to occur on

the test piece of the curable resin film having a diameter of 8 mm and a thickness of 1 mm under the conditions of a temperature of 90°C and a frequency of 1 Hz and measuring the shear modulus G' of the test piece of the curable resin film.

As described above, each of the test pieces subjected to the distortion dispersion measurement is a form of a circular film.

[0021]

The first protective film forming sheet of the present invention is used by being attached to the surface (in the present specification, referred to as a “bump-formed surface” in some cases) having the bump of the semiconductor wafer via the curable resin film. At this time, by attaching the curable resin film on the bump-formed surface while heating, the curable resin film softens, spreads between the bumps so as to cover the bumps, closely adheres to the bump-formed surface, and covers a surface of the bump, in particular, the surface of the vicinity of the bump-formed surface, and buries into the bump. After this, the curable resin film in this state is cured and finally forms a first protective film. Then, the first protective film protects the bump-formed surface and the bump in a state of being in close contact with the bump-formed surface and the surface of the bump. The semiconductor wafer on which the first protective film forming sheet is attached is finally incorporated into a semiconductor device in a state of a semiconductor chip provided with the first protective film after grinding a surface on the side opposite to the bump-formed surface, removing the first base member and the buffer layer, and then forming the first protective film.

[0022]

By using the first protective film forming sheet of the present invention, it is possible to limit the residual of the curable resin film on the upper portion of the bump when the curable resin film is attached to the bump-formed surface of the semiconductor

wafer. The reason for this is that the curable resin film and the buffer layer satisfy the relationship represented by Expression (w1). At the stage where the degree of distortion of the curable resin film and the buffer layer greatly differs from that at the initial stage of attachment after the middle stage of attaching the first protective film forming sheet to the semiconductor wafer, the shear modulus of these (the curable resin film and the buffer layer) has a specific relationship as described above, and thereby the upper portion of the bump can easily penetrate and protrude through the curable resin film.

[0023]

The first protective film forming sheet satisfies the relationship represented by Expression (w1). That is, test pieces having a diameter of 8 mm and a thickness of 1 mm are prepared for the buffer layer and the curable resin film constituting the first protective film forming sheet, and the distortion is caused to occur on the test piece under the conditions of the temperature of 90°C and the frequency of 1 Hz so as to perform the distortion dispersion measurement for measuring the shear modulus G' of the test piece. As such, in the present invention, shear modulus G_{b300}' of the test piece of the buffer layer when the distortion of the test piece of the buffer layer is 300%, and the shear modulus G_{c300}' of the test piece of the curable resin film when the distortion of the test piece of the curable resin film is 300% satisfy a relationship represented by $G_{b300}' \geq G_{c300}'$.

[0024]

When attaching the first protective film forming sheet to the bump-formed surface of the semiconductor wafer, in the initial stage and the stage after the middle stage of this attachment, the degree of distortion of the buffer layer constituting the sheet and the degree of distortion of the curable resin film are greatly different from each other.

That is the reason why a value (G_{b300}' , G_{c300}') when the distortion of these test pieces is 300% is employed as the shear modulus G' of the test piece of the buffer layer and the curable resin film in order to specify the present invention. As for the buffer layer, if the degree of distortion is different, the physical properties of a portion of the buffer layer greatly changes. Similarly, if the degree of the distortion of the curable resin film is different, the physical properties of a portion of the curable resin film also greatly change. In order to limit the residual of the curable resin film on the upper portion of the bump when the curable resin film is attached to the bump-formed surface, in the attachment stages for the curable resin film, particularly in a stage (in other words, a stage after the middle stage of attachment or a stage where the degree of the distortion in the buffer layer and the curable resin film becomes larger to some extent) where the upper portion of the bump tries to penetrate and protrude through the curable resin film, it is important to define the relationship of the shear modulus G' between the buffer layer and the curable resin film. For this reason, in the present invention, the relationship represented by Expression (w1) is satisfied. Each of G_{b300}' and G_{c300}' is the shear modulus G' of the buffer layer and the curable resin film at the stage when the degree of these distortions becomes larger.

[0025]

The first protective film forming sheet may satisfy the relationship represented by Expression (w1), in other words, the value of G_{b300}'/G_{c300}' may be 1 or more. From the viewpoint that the above effect of the present invention is further enhanced, the value of G_{b300}'/G_{c300}' is preferably larger than 1, is more preferably 10 or larger, and is still more preferably 100 or larger. For example, it may be 1000 or larger.

[0026]

In the first protective film forming sheet, both of the shear modulus G' of the

buffer layer and the shear modulus G' of the test piece of the buffer layer can be easily adjusted by adjusting the kinds or contents components contained in the buffer layer.

For that purpose, it is only necessary to adjust the kinds or amounts of components contained in a buffer layer forming composition, which will be described later, for

305 forming the buffer layer. For example, it is preferable to adjust the kind or amount of the main component such as poly α -olefin in a buffer layer forming composition (V) to be described later.

[0027]

In the first protective film forming sheet, both of the shear modulus G' of the
 310 curable resin film and the shear modulus G' of the test piece of the curable resin film can be easily adjusted by adjusting the kinds and contents components contained in the curable resin film. For that purpose, it is only necessary to adjust the kinds or amounts of components contained in a curable resin film forming composition, which will be described later, for forming the curable resin film. For example, in a case of using a
 315 resin layer forming composition (III) to be described later, it is preferable to adjust the kind or amount of the main component such as a polymer component (A), a thermosetting component (B), a curing accelerator (C), or a filler (D) in the composition.

[0028]

Further, it is preferable that the first protective film forming sheet satisfies a
 320 relationship represented by Expression (w2) at the time of performing the distortion dispersion measurement.

$$Gb200' \geq Gc200' \quad (w2)$$

[0029]

Here, $Gb200'$ is a shear modulus of the test piece of the buffer layer when the
 325 distortion of the test piece of the buffer layer is 200%. Further, $Gc200'$ is a shear

modulus of the test piece of the curable resin film when the distortion of the test piece of the curable resin film is 200%.

The first protective film forming sheet satisfying the relationship represented by Expression (w2) has a higher effect of limiting the residual of the curable resin film on the upper portion of the bump when the curable resin film is attached to the bump-formed surface.

[0030]

The first protective film forming sheet preferably satisfies the relationship represented by Expression (w2), in other words, the value of G_{b200}'/G_{c200}' is preferably 1 or more. From the viewpoint that the above effect of the present invention is further enhanced, the value of G_{b200}'/G_{c200}' is more preferably 1 or more, is still more preferably 10 or more, and is particularly preferably 100 or more. Also, it may be 1000 or more, for example.

[0031]

The first protective film forming sheet preferably satisfies a relationship represented by Expression (w3) when the distortion dispersion measurement is performed.

$$G_{b400}' \geq G_{c400}' \quad (w3)$$

[0032]

Here, G_{b400}' is a shear modulus of the test piece of the buffer layer when the distortion of the test piece of the buffer layer is 400%. Further, G_{c400}' is a shear modulus of the test piece of the curable resin film when the distortion of the test piece of the curable resin film is 400%.

The first protective film forming sheet satisfying the relationship represented by Expression (w3) has a higher effect of limiting the residual of the curable resin film on

the upper portion of the bump when the curable resin film is attached to the bump-formed surface.

[0033]

The first protective film forming sheet preferably satisfies the relationship
355 represented by Expression (w3), in other words, the value of G_b400'/G_c400' is preferably 1 or more. From the viewpoint that the above effect of the present invention is further enhanced, the value of G_b400'/G_c400' is more preferably 1 or more, is still more preferably 10 or more, and is particularly preferably 100 or more. Also, it may be 1000 or more, for example.

360 [0034]

From the viewpoint that the above effect of the present invention is further enhanced, the first protective film forming sheet satisfies the relationship represented by Expression (w1), and preferably satisfies at least one of relationships represented by Expressions (w2) and (w3), and more preferably satisfies all of relationships of
365 Expressions (w1), (w2), and (w3).

[0035]

Regarding the first protective film forming sheet, in a function (in the present specification, referred to as “function Fb” in some cases) of the distortion of the test piece of the buffer layer and the shear modulus G_b' of the test piece of the buffer layer
370 which are obtained by the distortion dispersion measurement, a region (in the present specification, referred to as “variable region Rb” in some cases) where the shear modulus G_b' is not constant preferably exists, and the shear modulus G_b' when the distortion of the test piece of the buffer layer is 300% is more preferably included in the region (variable region Rb). Such a first protective film forming sheet has a higher effect of
375 limiting the residual of the curable resin film on the upper portion of the bump when the

curable resin film is attached to the bump-formed surface.

[0036]

Regarding the first protective film forming sheet, in a function (in the present specification, referred to as a “function Fc” in some cases) of the distortion of the test
 380 piece of the curable resin film obtained by the distortion dispersion measurement and the shear modulus Gc’ of the test piece of the curable resin film, a region (in the present specification, referred to as a “variable region Rc” in some cases) where the shear modulus Gc’ is not constant preferably exists, and the shear modulus Gc’ when the distortion of the test piece of the curable resin film is 300% is more preferably included
 385 in the region (variable region Rc). Such a first protective film forming sheet has a higher effect of limiting the residual of the curable resin film on the upper portion of the bump when the curable resin film is attached to the bump-formed surface.

[0037]

Regarding the first protective film forming sheet, from the viewpoint that the
 390 above effect of the present invention is further enhanced, it is preferable that the variable region Rb exists in the function Fb, and the variable region Rc exists in the function Fc, and it is more preferable that the shear modulus Gb’ when the distortion of the test piece of the buffer layer is 300% is included in the variable region Rb, and the shear modulus Gc’ when the distortion of the test piece of the curable resin film is 300% is included in
 395 the variable region Rc.

[0038]

Note that, in the present specification, the phrase “shear modulus is not constant” means that “the minimum value (Pa) of the shear modulus is less than 90% of the maximum value (Pa) of the shear modulus (a value of [the minimum value (Pa) of the
 400 shear modulus]/[maximum value (Pa) of the shear modulus] × 100 is less than 90)” in the

region to be a target. In other words, the phrase “the shear modulus is constant” means that “the minimum value (Pa) of the shear modulus is 90% or more than the maximum value (Pa) of the shear modulus” in the region to be a target.

[0039]

405 In the function Fb of the first protective film forming sheet, whether or not the variable region Rb exists can be easily adjusted by adjusting the kinds and contents components contained in the buffer layer similar to the case of the above-described shear modulus G’.

[0040]

410 In the function Fc of the first protective film forming sheet, whether or not the variable region Rc exists can be easily adjusted by adjusting the kinds and contents components contained in the curable resin film similar to the case of the above-described shear modulus G’.

[0041]

415 FIG. 1 is a cross-sectional view schematically showing an embodiment of the first protective film forming sheet of the present invention. Note that, in the drawings used in the following description, for the sake of easy understanding of the features of the present invention, and for the sake of convenience, a portion serving as a main part is sometimes enlarged and the dimensional ratio and the like of each component is not
420 necessarily the same as the actual one.

[0042]

The first protective film forming sheet 1 as shown in FIG. 1 includes a first base member 11, a buffer layer 13 formed on the first base member 11, and a curable resin film 12 formed on the buffer layer 13.

425 More specifically, on the first protective film forming sheet 1, the buffer layer 13

is stacked on one surface (hereinafter, referred to as a “first surface” in some cases) 11a of the first base member 11, and the curable resin film 12 is stacked on a surface (hereinafter, referred to as a “first surface” in some cases) 13a on the opposite to the side on which the first base member 11 of the buffer layer 13 is provided. As such, the first protective film forming sheet 1 is obtained by stacking the first base member 11, the buffer layer 13, and the curable resin film 12 in this order in the thickness direction thereof. In FIG. 1, a reference numeral 12a indicates a surface (hereinafter, referred to as a “first surface” in some cases) on the side opposite to the side on which the buffer layer 13 of the curable resin film 12 is provided.

[0043]

FIG. 2 is a cross-sectional view schematically showing another embodiment of the first protective film forming sheet of the present invention.

In the figures after FIG. 2, the same reference numerals are given to the same constituent elements as those shown in the already described figures, and a detailed description thereof will be not be repeated.

[0044]

A first protective film forming sheet 2 as shown in FIG. 2 is the same as the first protective film forming sheet 1 as shown in FIG. 1 except that an adhesion layer 14 is provided between the first base member 11 and the buffer layer 13 (the adhesion layer 14 formed on the first base member 11 and the buffer layer 13 formed on the adhesion layer 14).

That is, the first protective film forming sheet 2 is obtained by stacking the buffer layer 13 on a surface (hereinafter, referred to as “first surface” in some cases) 14a opposite to the side on which the adhesion layer 14 is stacked on the first surface 11a of the first base member 11, and the first base member 11 of the adhesion layer 14 is

provided, which means the first base member 11, the adhesion layer 14, the buffer layer 13, and the curable resin film 12 are stacked in this order in the thickness direction thereof.

[0045]

455 The first protective film forming sheet of the present invention is not limited to those shown in FIGS. 1 and 2, and a configuration in which a part of the configuration is changed, deleted, or added in those shown in FIGS. 1 and 2 may be used as long as the effects of the present invention are not impaired.

 For example, the first protective film forming sheet of the present invention may
460 be provided with a peeling film on the outermost layer on the side opposite to the base member (curable resin film 12 in the first protective film forming sheet as shown in FIGS. 1 and 2).

 Then, each layer constituting the first protective film forming sheet of the present invention will be described.

465 [0046]

- First Base member

 The first base member is in a sheet-form or film-form base member, and examples of a constituent material thereof include a variety of resins.

 Examples of the resins include polyethylene such as low-density polyethylene
470 (LDPE), linear low-density polyethylene (LLDPE), and high-density polyethylene (HDPE); polyolefin other than polyethylene such as polypropylene, polybutene, polybutadiene, polymethylpentene, and norbornene resins; ethylene-based copolymers (copolymers obtained using ethylene as monomers) such as ethylene-vinyl acetate copolymers, ethylene-(meth)acrylate copolymers, ethylene-(meth)acrylic acid ester
475 copolymers, and ethylene-norbornene copolymers; vinyl chloride-based resins (resins

obtained using vinyl chloride as monomers) such as polyvinyl chloride and vinyl chloride copolymers; polystyrene; polycycloolefin; polyesters such as polyethylene terephthalate, polyethylene naphthalate, polybutylene terephthalate, polyethylene isophthalate, polyethylene-2,6-naphthalene dicarboxylate, and wholly aromatic polyesters in which all
480 constituent units have an aromatic cyclic group; copolymers of two or more polyester described above; poly(meth)acrylic acid esters; polyurethane; polyurethane acrylate; polyimide; polyamide; polycarbonate; fluororesin; polyacetal; modified polyphenylene oxides; polyphenylene sulfides; polysulfone; and polyether ketones.

In addition, examples of the resins also include polymer alloys such as mixtures
485 of the polyester and other resin. The polymer alloys of the polyester and other resin are preferably polymer alloys in which the amount of the resin other than the polyester is relatively small.

In addition, examples of the resins material also include crosslinked resins in which one or more resins exemplified above are crosslinked with each other; modified
490 resins such as ionomers for which one or more resins exemplified above are used; and the like.

[0047]

Meanwhile, in the present specification, “(meth)acrylic acid” refers to both “acrylic acid” and “methacrylic acid”. What has been described above is also true for
495 terminologies similar to (meth)acrylic acid, for example, “(meth)acrylate” refers to both “acrylate” and “methacrylate”, and “a (meth)acryloyl group” refers to both “an acryloyl group” and “a methacryloyl group”.

[0048]

Only one kind or two or more kinds of resins may constitute the first base
500 member, and in a case in which two or more kinds of resins constitute the first base

member, the combination and ratio thereof can be optionally selected.

[0049]

The first base member may be a single layer (monolayer) or a plurality of layers (two or more layers), and in a case in which the first base member is a plurality of layers, 505 the respective layers in the plurality of layers may be identical to or different from one another, and the combination of the plurality of layers is not particularly limited.

Meanwhile, in the present specification, the sentence “a plurality of layers may be identical to or different from one another” means that “all of the layers may be identical to one another, all of the layers may be different from one another, or only some 510 of the layers may be identical to one another”, and furthermore, the sentence “a plurality of layers is different from one another” means that “at least one of the constituent materials and the thicknesses of the respective layers are different from one another”, which will be true not only for the first base member but also for other elements.

[0050]

515 The thickness of the first base member is preferably 5 to 1,000 μm , more preferably 10 to 500 μm , still more preferably 15 to 300 μm , and particularly preferably 20 to 150 μm .

Here, “the thickness of the first base member” refers to the thickness of the entire first base member, and, for example, the thickness of the first base member made 520 up of a plurality of layers refers to the total thickness of all of the layers constituting the first base member.

[0051]

The first base member is preferably a first base member having a high accuracy in thickness, that is, a first base member in which the variation of the thickness is limited 525 throughout the entire portion. Among the above-described constituent materials,

examples of materials having a high accuracy in thickness that can be used to constitute the above-described first base member include polyethylene, polyolefin other than polyethylene, polyethylene terephthalate, ethylene-vinyl acetate copolymers, and the like.

[0052]

530 The first base member may also contain, in addition to the main constituent material such as the resin, a variety of well-known additives such as a filler, a colorant, an antistatic agent, an antioxidant, an organic lubricant, a catalyst, and a softening agent (plasticizer).

[0053]

535 The first base member may be transparent or opaque and may be colored depending on the purpose. In addition, other layers may be deposited on the first base member.

In a case in which the curable resin film is energy ray-curable, the first base member preferably transmits energy rays.

540 [0054]

The first base member can be manufactured using a well-known method. For example, the first base member containing the resin can be manufactured by forming a resin composition containing the resin.

[0055]

545 • Buffer Layer

The buffer layer has a buffer action against the force applied to the buffer layer and the layer adjacent thereto. Here, “a layer adjacent to the buffer layer” is mainly a curable resin film and a first protective film corresponding to the cured product.

[0056]

550 The buffer layer is in the sheet-form or film-form, and a constituent material

thereof is not particularly limited as long as it satisfies the relationship represented by Expression (w1).

[0057]

Preferable buffer layers include those containing various resins such as poly
555 α -olefin, for example.

[0058]

The buffer layer may be a single layer (monolayer) or a plurality of two or more
layers. In a case in which the buffer layer is a plurality of layers, the respective layers
in the plurality of layers may be identical to or different from one another, and the
560 combination of the plurality of layers is not particularly limited.

[0059]

The thickness of the buffer layer is preferably 150 to 1,000 μm , more preferably
150 to 800 μm , still more preferably 200 to 600 μm , and particularly preferably 250 to
500 μm .

565 Here, "the thickness of the buffer layer" refers to the thickness of the entire
buffer layer, and, for example, the thickness of the buffer layer made up of a plurality of
layers refers to the total thickness of all of the layers constituting the buffer layer.

[0060]

<<Buffer layer forming composition>>

570 The buffer layer can be formed using a buffer layer forming composition
containing a constituent material of the buffer layer of the resin or the like. For example,
the buffer layer can be formed at a target site by extruding a buffer layer forming
composition to a target surface on which the buffer layer is to be formed. A more
specific method for forming the buffer layer will be described below in detail together
575 with methods for forming other layers. The ratio between the amounts of components,

which do not gasify at normal temperature, in the buffer layer forming composition is, generally, identical to the ratio between the amounts of the above-described components in the buffer layer forming composition. Meanwhile, in the present specification, “normal temperature” refers to a temperature that is not particularly cooled or heated, that is, a temperature in an ordinary state, and examples thereof include a temperature of 15°C to 25°C and the like.

[0061]

<Buffer Layer Forming Composition (V)>

Examples of the buffer layer forming composition include a buffer layer forming composition (V) containing poly α -olefin.

[0062]

The poly α -olefin may be one having a constituent unit derived from α -olefin.

The poly α -olefin may have only one kind or two or more kinds of constituent units, and in a case in which the poly α -olefin has two or more kinds of constituent units, the combination and ratio thereof can be optionally selected. That is, poly α -olefin may be a homopolymer formed by polymerizing one kind of monomer, or a copolymer obtained by copolymerization of two or more kinds of monomers.

[0063]

The poly α -olefin is preferably an ethylene- α -olefin copolymer.

[0064]

A density of the poly α -olefin is preferably 890 kg/m³ or lower, is more preferably 830 to 890 kg/m³, and is particularly preferably 850 to 875 kg/m³. Note that, in the present specification, “density of the poly α -olefin” means a value measured in accordance with ASTM D1505 unless otherwise specified.

[0065]

Specifically, a melting point of the poly α -olefin is preferably 55°C or lower, and is more preferable 50°C or lower.

[0066]

A melt flow rate (MFR) of the poly α -olefin at 190°C is preferably 1 to 6 g/10 min, and is more preferably 2.5 to 4.5 g/10 min.

In addition, a melt flow rate (MFR) of the poly α -olefin at 230°C is preferably 2 to 12 g/10 min, and is more preferably 4 to 9 g/10 min.

Note that, in the present specification, “melt flow rate of the poly α -olefin” means a value measured in accordance with ASTM D1238 unless otherwise specified.

[0067]

The amount of the poly α -olefin in the buffer layer forming composition (V) and the buffer layer is preferably 80% to 100% by mass.

[0068]

[Other Components]

The buffer layer forming composition (V) and the buffer layer may contain other components in addition to the poly α -olefin as long as the effects of the present invention are not impaired.

The above other components are not particularly limited and can be appropriately selected depending on the purpose.

[0069]

The buffer layer forming composition (V) and the buffer layer may contain only one kind or two or more kinds of the above other components, and in a case in which the buffer layer forming composition and the buffer layer contain two or more kinds of the crosslinking agents, a combination and a ratio thereof can be optionally selected.

625 The amount of the above other components in the buffer layer forming
composition (V) and the buffer layer is not particularly limited and may be appropriately
selected depending on the purpose.

[0070]

- Curable Resin Film

630 The curable resin film is a layer for protecting the bump-formed surface (in
other words, circuit surface) of the semiconductor wafer and the bump provided on the
bump-formed surface, is a thermosetting resin film in the first aspect and is an energy
ray-curable resin film in the second aspect. The curable resin film forms the first
protective film by curing.

635 [0071]

The curable resin film is in the sheet-form or film-form, and a constituent
material thereof is not particularly limited as long as it satisfies the relationship
represented by Expression (w1).

640 The curable resin film may be either thermosetting or energy ray-curable, but is
preferably thermosetting.

[0072]

Note that, in the present invention, “energy rays” refer to rays having energy
quanta in electromagnetic waves or charged particle radiation, and examples thereof
include ultraviolet rays, radiations, electron beams, and the like.

645 Ultraviolet rays can be irradiated using, for example, a high-pressure mercury
lamp, a fusion H lamp, a xenon lamp, black light, a LED lamp, or the like as an
ultraviolet ray source. As the electron beams, electron beams generated using an
electron beam accelerator or the like can be radiated.

In the present invention, “being energy ray-curable” refers to a property of being

650 cured by irradiation with energy rays, and “being non-energy ray-curable” refers to a property of not being cured by irradiation with energy rays.

[0073]

The curable resin film contains a resin component, and may contain or may not contain a filler in addition to the resin component. The amount of the filler is preferably
655 45% by mass or less.

[0074]

In the curable resin film, a weight-average molecular weight of the resin component is preferably 1,000,000 or less, and for example, it may be 800,000 or less, 500,000 or less, 300,000 or less, 200,000 or less, 100,000 or less, 50,000 or less, or
660 30,000 or less.

On the other hand, in the curable resin film, a lower limit value of the weight-average molecular weight of the resin component is not particularly limited, and for example, it may be 5,000 or 8,000.

When the resin component satisfies the above conditions, the first protective
665 film forming sheet has a higher effect of limiting the residual of the curable resin film on the upper portion of the bump.

In the present specification, unless particularly otherwise described, the weight-average molecular weight refers to a polystyrene-equivalent value measured using gel permeation chromatography (GPC).

670 [0075]

The weight-average molecular weight of the resin component can be appropriately adjusted so as to be within a range set optionally combining the above-mentioned preferable lower limit value and upper limit value.

The preferable weight-average molecular weight is 5,000 to 1,000,000, 5,000 to

675 800,000, 5,000 to 500,000, 5,000 to 300,000, 5,000 to 200,000, 5,000 to 100,000, 5,000 to 50,000, and 5,000 to 30,000.

As examples of the preferable weight-average molecular weight, it is 8,000 to 1,000,000, 8,000 to 800,000, 8,000 to 500,000, 8,000 to 300,000, 8,000 to 200,000, 8,000 to 100,000, 8,000 to 50,000, and 8,000 to 30,000.

680 However, the weight-average molecular weight is not limited thereto.

[0076]

The amount of the filler of the curable resin film is more preferably 40% by mass or less, and is particularly preferably 30% by mass or less.

On the other hand, a lower limit value of the amount of the filler of the curable
685 resin film is not particularly limited. For example, the amount of the filler of the curable resin film may be 0% by mass or more, 5% by mass or more, and 10% by mass or more.

[0077]

The amount of the filler of the curable resin film can be appropriately adjusted
690 so as to be within a range set optionally combining the above-mentioned preferable lower limit value and an upper limit value.

The preferable amount of the filler of the curable resin film is, for example, 0% to 45% by mass, 0% to 40% by mass, and 0% to 30% by mass.

However, the amount of the filler of the curable resin film is not limited to these.

695 [0078]

The curable resin film contains a resin component, the amount of the filler is 45% by mass or less, the weight-average molecular weight of the resin component is particularly preferably 30,000 or lower. When satisfying the above conditions, the first protective film forming sheet has a higher effect of limiting the residual of the curable

700 resin film on the upper portion of the bump.

The kinds of the resin component and the filler are not particularly limited.

As such a curable resin film, for example, those contain a resin component, and in which the amount of the filler is preferably 0% to 45% by mass, is more preferably 0% to 40% by mass, and is still more preferably 0% to 30% by mass, and the weight-average
705 molecular weight of the resin component is 30,000 or less (for example, 5,000 to 30,000, and 8,000 to 30,000).

[0079]

The curable resin film can be formed using the curable resin film forming composition containing a constituent material thereof. For example, components
710 corresponding to the resins in the thermosetting resin film forming composition and the energy ray-curable resin film forming composition which will be described later all contain in the resin component.

[0080]

◆ Thermosetting Resin Film

715 Examples of a preferred thermosetting resin film include thermosetting resin films which contain a polymer component (A) as the resin component and further contain a thermosetting component (B).

[0081]

The thermosetting resin film may be a single layer (monolayer) or a plurality of
720 layers of two or more layers, and in a case in which the thermosetting resin film is a plurality of layers, the respective layers in the plurality of layers may be identical to or different from one another, and the combination of the plurality of layers is not particularly limited.

[0082]

725 The thickness of the thermosetting resin film is preferably 1 to 100 μm , more preferably 5 to 75 μm , and particularly preferably 5 to 50 μm . When the thickness of the thermosetting resin film is equal to or more than the lower limit value, it is possible to form a first protective film having a higher protection function. In addition, when the thickness of the thermosetting resin film is equal to or less than the upper limit value, 730 excessive thickness is limited.

Here, “the thickness of the thermosetting resin film” refers to the thickness of the entire thermosetting resin film, and, for example, the thickness of the thermosetting resin film made up of a plurality of layers refers to the total thickness of all of the layers constituting the thermosetting resin film.

735 [0083]

<<Thermosetting resin film forming composition>>

The thermosetting resin film can be formed using the thermosetting resin film forming composition containing a constituent material thereof. For example, the thermosetting resin film can be formed at an intended portion by applying the 740 thermosetting resin film forming composition to a target surface on which the thermosetting resin film is to be formed and drying the thermosetting resin composition as necessary. A more specific method for forming the thermosetting resin film will be described below in detail together with methods for forming other layers. The ratio between the amounts of components, which do not gasify at normal temperature, in the 745 thermosetting resin film forming composition is, generally, identical to the ratio between the amounts of the above-described components in the thermosetting resin film.

[0084]

The thermosetting resin film forming composition may be applied using a well-known method, and examples of the method include methods in which a variety of

750 coaters such as an air knife coater, a blade coater, a bar coater, a gravure coater, a roll
coater, a roll knife coater, a curtain coater, a die coater, a knife coater, a screen coater, a
Mayer bar coater, and a kiss coater are used.

[0085]

755 The drying conditions of the thermosetting resin film forming composition are
not particularly limited; however, in a case in which the thermosetting resin film forming
composition contains a solvent described below, the thermosetting resin film forming
composition is preferably heated and dried. The thermosetting resin film forming
composition containing a solvent is preferably dried at 70°C to 130°C for 10 seconds to 5
minutes.

760 [0086]

<Resin Layer Forming Composition (III)>

Examples of the thermosetting resin film forming composition include a
thermosetting resin film forming composition (III) containing the polymer component
(A) and the thermosetting component (B) (in the present specification, in some cases,
765 simply abbreviated as “the resin layer forming composition (III)”) and the like.

[0087]

[Polymer Component (A)]

770 The polymer component (A) is a polymer compound for imparting film-forming
properties, flexibility, and the like to the thermosetting resin film, and is a component that
can be regarded as being formed by polymerization reaction of the polymerizable
compound. Meanwhile, in the present specification, a polycondensation reaction is also
considered as the polymerization reaction.

The resin layer forming composition (III) and the thermosetting resin film may
contain only one kind or two or more kinds of the polymer components (A), and in a case

775 in which the resin layer forming composition and the thermosetting resin film contain two or more kinds of the polymer components, the combination and ratio thereof can be optionally selected.

[0088]

Examples of the polymer component (A) include an acrylic resin (a resin having
780 a (meth)acryloyl group), a polyvinyl acetal, and the like.

[0089]

Examples of the acrylic resin in the polymer component (A) include well-known acrylic polymers.

The weight-average molecular weight (M_w) of the acrylic resin is preferably
785 5,000 to 1,000,000, and is more preferably 8,000 to 800,000. When the weight-average molecular weight of the acrylic resin is within the above range, the effect of limiting the residual of the curable resin film on the upper portion of the bump becomes higher when the curable resin film is attached to the bump-formed surface.

[0090]

790 The glass transition temperature (T_g) of the acrylic resin is preferably -50°C to 70°C and more preferably -30°C to 60°C . When the glass transition temperature (T_g) of the acrylic resin is within the above range, the effect of limiting the residual of the curable resin film on the upper portion of the bump becomes higher when the curable resin film is attached to the bump-formed surface.

795 [0091]

The acrylic resin may be constituted of only one kind or two or more kinds of monomers, and in a case in which the acrylic resin is constituted of two or more kinds of monomers, the combination and ratio thereof can be optionally selected.

[0092]

800 Examples of the acrylic resin include polymers of one or more kinds of
 (meth)acrylic acid esters; copolymers of two or more kinds of monomers selected from
 (meth)acrylic acid, itaconic acid, vinyl acetate, acrylonitrile, styrene, N-methylol
 acrylamide, and the like; and copolymers of one or more kinds of (meth)acrylic acid
 esters and one or more monomers selected from (meth)acrylic acid, itaconic acid, vinyl
 805 acetate, acrylonitrile, styrene, and N-methylol acrylamide.

[0093]

 Examples of the (meth)acrylic acid esters constituting the acrylic resin include
 alkyl (meth)acrylic acid esters in which an alkyl group constituting the alkyl ester has 1
 to 18 carbon atoms and has a chain-like shape such as methyl (meth)acrylate, ethyl
 810 (meth)acrylate, n-propyl (meth)acrylate, isopropyl (meth)acrylate, n-butyl (meth)acrylate,
 isobutyl (meth)acrylate, sec-butyl (meth)acrylate, tert-butyl (meth)acrylate, pentyl
 (meth)acrylate, hexyl (meth)acrylate, heptyl (meth)acrylate, 2-ethylhexyl (meth)acrylate,
 isooctyl (meth)acrylate, n-octyl (meth)acrylate, n-nonyl (meth)acrylate, isononyl
 (meth)acrylate, decyl (meth)acrylate, undecyl (meth)acrylate, dodecyl (meth)acrylate
 815 (lauryl (meth)acrylate), tridecyl (meth)acrylate, tetradecyl (meth)acrylate (myristyl
 (meth)acrylate), pentadecyl (meth)acrylate, hexadecyl (meth)acrylate (palmityl
 (meth)acrylate), heptadecyl (meth)acrylate, and octadecyl (meth)acrylate (stearyl
 (meth)acrylate), and the like; cycloalkyl (meth)acrylic acid esters such as isobornyl
 (meth)acrylate and dicyclopentanyl (meth)acrylate; aralkyl (meth)acrylic acid esters such
 820 as benzyl (meth)acrylate; cycloalkenyl (meth)acrylic acid esters such as dicyclopentenyl
 (meth)acrylate; cycloalkenyloxy alkyl (meth)acrylic acid esters such as
 dicyclopentenylloxyethyl (meth)acrylate; imide (meth)acrylate; glycidyl group-containing
 (meth)acrylic acid esters such as glycidyl (meth)acrylate; hydroxyl group-containing
 (meth)acrylic acid esters such as hydroxymethyl (meth)acrylate, 2-hydroxyethyl

825 (meth)acrylate, 2-hydroxypropyl (meth)acrylate, 3-hydroxypropyl (meth)acrylate,
2-hydroxybutyl (meth)acrylate, 3-hydroxybutyl (meth)acrylate, and 4-hydroxybutyl
(meth)acrylate; and substituted amino group-containing (meth)acrylic acid esters such as
N-methylaminoethyl (meth)acrylate; and the like. Here, “the substituted amino group”
refers to a group formed by substituting one or two hydrogen atoms in an amino group
830 with a group other than a hydrogen atom.

[0094]

The acrylic resin may also have a functional group capable of bonding to other
compounds such as a vinyl group, a (meth)acryloyl group, an amino group, a hydroxyl
group, a carboxy group, or an isocyanate group. The functional group in the acrylic
835 resin may be bonded to other compounds through a crosslinking agent (F) described
below or may be directly bonded to other compounds without the crosslinking agent (F).
When the acrylic resin is bonded to other compounds through the functional group, there
is a tendency that the reliability of packages obtained using the first protective film
forming sheet improves.

840 [0095]

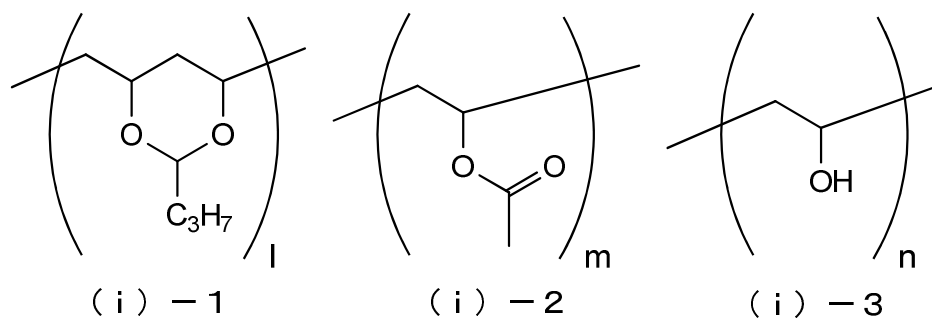
Examples of the polyvinyl acetal in the polymer component (A) include
well-known substances.

Among them, preferable polyvinyl acetals include, for example, polyvinyl
formal and polyvinyl butyral, and polyvinyl butyral is more preferable.

845 Examples of the polyvinyl butyral include those having constituent units
represented by Formulae (i)-1, (i)-2, and (i)-3.

[0096]

[Chem. 1]



850 (In Formula, l, m, and n are each independently an integer of 1 or more.)

[0097]

The weight-average molecular weight (Mw) of the polyvinyl acetal is preferably 5,000 to 200,000, and is more preferably 8,000 to 100,000. When the weight-average molecular weight of the polyvinyl acetal is within the above range, the effect of limiting
 855 the residual of the curable resin film on the upper portion of the bump becomes higher when the curable resin film is attached to the bump-formed surface.

[0098]

The glass transition temperature (Tg) of the polyvinyl acetal is preferably 40°C to 80°C and is more preferably 50°C to 70°C. When the Tg of the polyvinyl acetal is
 860 within the above range, the effect of limiting the residual of the curable resin film on the upper portion of the bump becomes higher when the curable resin film is attached to the bump-formed surface.

[0099]

The ratio of three or more kinds of monomers constituting the polyvinyl acetal
 865 can be optionally selected.

[0100]

In the resin layer forming composition (III), the ratio of the amount of the polymer component (A) (that is, the amount of the polymer component (A) in the thermosetting resin film) to the total amount of all of the components other than the

870 solvent is preferably 5% to 25% by mass and more preferably 5% to 15% by mass
regardless of the kind of the polymer component (A).

[0101]

[Thermosetting component (B)]

The thermosetting component (B) is a component for curing the thermosetting
875 resin film so as to form a rigid first protective film with heat as a trigger of reaction.

The resin layer forming composition (III) and the thermosetting resin film may
contain only one kind or two or more kinds of the thermosetting components (B), and in
a case in which the resin layer forming composition and the thermosetting resin film
contain two or more kinds of the thermosetting components, the combination and ratio
880 thereof can be optionally selected.

[0102]

The thermosetting component (B) is preferably epoxy-based thermosetting resin.

[0103]

(Epoxy-Based Thermosetting Resin)

885 The epoxy-based thermosetting resin is made up of an epoxy resin (B1) and a
thermal curing agent (B2).

The resin layer forming composition (III) and the thermosetting resin film may
contain only one kind or two or more kinds of the epoxy-based thermosetting resins, and
in a case in which the resin layer forming composition and the thermosetting resin film
890 contains two or more kinds of the epoxy-based thermosetting resins, the combination and
ratio thereof can be optionally selected.

[0104]

· Epoxy resin (B1)

As the epoxy resin (B1), well-known epoxy resins can be exemplified.

895 Examples thereof include polyfunctional epoxy resins, biphenyl compounds, bisphenol A diglycidyl ethers and hydrogenated substances thereof, orthocresol novolac epoxy resins, dicyclopentadiene-type epoxy resins, biphenyl-type epoxy resins, bisphenol A-type epoxy resins, bisphenol F-type epoxy resins, phenylene skeleton-type epoxy resins, and the like, and di- or higher-functional epoxy compounds.

900 [0105]

As the epoxy resin (B1), an epoxy resin having an unsaturated hydrocarbon group may also be used. The epoxy resin having an unsaturated hydrocarbon group has more compatibility with acrylic resins than epoxy resins not having an unsaturated hydrocarbon group. Therefore, when the epoxy resin having an unsaturated hydrocarbon group is used, the reliability of packages obtained using the first protective film forming sheet improves.

[0106]

Examples of the epoxy resin having an unsaturated hydrocarbon group include compounds formed by converting a part of epoxy groups in a polyfunctional epoxy resin to groups having an unsaturated hydrocarbon group. The above-described compound can be obtained by, for example, an addition reaction of (meth)acrylic acid or a derivative thereof to an epoxy group.

In addition, examples of the epoxy resin having an unsaturated hydrocarbon group include compounds in which a group having an unsaturated hydrocarbon group is directly bonded to an aromatic ring or the like constituting an epoxy resin and the like.

The unsaturated hydrocarbon group is a polymerizable unsaturated group, and specific examples thereof include ethenyl groups (vinyl groups), 2-propenyl group (allyl group), (meth)acryloyl groups, (meth)acrylamide groups, and the like, and acryloyl groups are preferred.

920 [0107]

The number-average molecular weight of the epoxy resin (B1) is not particularly limited, but is preferably 300 to 30,000, is more preferably 400 to 10,000, and is particularly preferably 500 to 3,000 from the viewpoint of the curing property of the thermosetting resin film and the strength and thermal resistance of the first protective
925 film.

The epoxy equivalent of the epoxy resin (B1) is preferably 100 to 1,000 g/eq and more preferably 300 to 800 g/eq.

[0108]

The epoxy resin (B1) may be used singly or two or more kinds thereof may be
930 jointly used, and in a case in which two or more kinds thereof are jointly used, the combination and ratio thereof can be optionally selected.

[0109]

· Thermal Curing Agent (B2)

The thermal curing agent (B2) functions as a curing agent of the epoxy resin
935 (B1).

Examples of the thermal curing agent (B2) include compounds having two or more functional groups capable of reacting with an epoxy group in one molecule.

Examples of the functional group include phenolic hydroxyl groups, alcoholic hydroxyl groups, an amino group, a carboxy group, groups in which an acid group is turned into an anhydride, and the like, phenolic hydroxyl groups, amino groups, or groups in which an
940 acid group is turned into an anhydride are preferred, and phenolic hydroxyl groups or amino groups are more preferred.

[0110]

As the thermal curing agent (B2), examples of phenolic curing agents having a

945 phenolic hydroxyl group include polyfunctional phenolic resins, biphenol, novolac-type phenolic resins, dicyclopentadiene-based phenolic resins, aralkylphenolic resins, and the like.

As the thermal curing agent (B2), examples of amine-based curing agents having an amino group include dicyandiamide (hereinafter, in some cases, abbreviated as 950 “DICY”), and the like.

[0111]

The thermal curing agent (B2) may also have an unsaturated hydrocarbon group.

Examples of the thermal curing agent (B2) having an unsaturated hydrocarbon group include compounds formed by substituting a part of hydroxyl groups in a phenolic 955 resin with groups having an unsaturated hydrocarbon group, compounds formed by directly bonding a group having an unsaturated hydrocarbon group to an aromatic ring of a phenolic resin, and the like.

The unsaturated hydrocarbon group in the thermal curing agent (B2) is identical to the unsaturated hydrocarbon group in the above-described epoxy resin having an 960 unsaturated hydrocarbon group.

[0112]

The number-average molecular weight of the resin component such as a polyfunctional phenolic resin, a novolac-type phenolic resin, a dicyclopentadiene-based phenolic resin, or an aralkylphenolic resin as the thermal curing agent (B2) is preferably 965 300 to 30,000, more preferably 400 to 10,000, and particularly preferably 500 to 3,000.

The molecular weight of a non-resin component, for example, biphenol or dicyandiamide as the thermal curing agent (B2) is not particularly limited, and is preferably, for example, 60 to 500.

[0113]

970 The thermal curing agent (B2) may be used singly or two or more kinds thereof may be jointly used, and in a case in which two or more kinds thereof are jointly used, the combination and ratio thereof can be optionally selected.

[0114]

 In the resin layer forming composition (III) and the thermosetting resin film, the
975 amount of the thermal curing agent (B2) is preferably 0.1 to 500 parts by mass, and is more preferably 1 to 200 parts by mass, and may be 1 to 150 parts by mass, 1 to 100 parts by mass, or 1 to 75 parts by mass with respect to the content (100 parts by mass) of the epoxy resin (B1). When the amount of the thermal curing agent (B2) is equal to or more than the lower limit value, it becomes easier for the curing of the thermosetting
980 resin film to proceed. In addition, when the amount of the thermal curing agent (B2) is equal to or less than the upper limit value, the moisture absorptivity of the thermosetting resin film is decreased, and thus the reliability of packages obtained by using the first protective film forming sheet further improves.

[0115]

985 In the resin layer forming composition (III) and the thermosetting resin film, the amount of the thermosetting component (B) (for example, a total amount of the epoxy resin (B1) and the thermal curing agent (B2)) is preferably 600 to 1,000 parts by mass with respect to the content (100 parts by mass) of the polymer component (A). When the amount of the thermosetting component (B) is within the above range, the effect of
990 limiting the residual of the curable resin film on the upper portion of the bump becomes higher, and a hard first protective film can be formed.

 Further, from the viewpoint that such effects can be more remarkably obtained, it is preferable that the amount of the thermosetting component (B) is appropriately adjusted depending on the kind of the polymer component (A).

995 [0116]

For example, in a case where the polymer component (A) is the above acrylic resin, in the resin layer forming composition (III) and the thermosetting resin film, the amount of the thermosetting component (B) is preferably 700 to 1000 parts by mass, is more preferably 750 to 1000 parts by mass, and is particularly preferably 750 to 900 parts by mass with respect to the content (100 parts by mass) of the polymer component (A).

[0117]

For example, in a case where the polymer component (A) is the above polyvinyl acetal, in the resin layer forming composition (III) and the thermosetting resin film, the amount of the thermosetting component (B) is preferably 600 to 1000 parts by mass, is more preferably 650 to 1000 parts by mass, and is particularly preferably 650 to 950 parts by mass with respect to the content (100 parts by mass) of the polymer component (A).

[0118]

1010 [Curing Accelerator (C)]

The resin layer forming composition (III) and the thermosetting resin film may also contain a curing accelerator (C). The curing accelerator (C) is a component for adjusting the resin layer forming composition (III).

Examples of preferred curing accelerators (C) include tertiary amines such as triethylene diamine, benzyldimethylamine, triethanolamine, dimethylaminoethanol, and tris(dimethylaminomethyl)phenol; imidazoles (imidazoles in which one or more hydrogen atoms are substituted with groups other than a hydrogen atom) such as 2-methylimidazole, 2-phenyl imidazole, 2-phenyl-4-methylimidazole, 2-phenyl-4,5-dihydroxymethylimidazole, and

1020 2,-phenyl-4-methyl-5-hydroxymethylimidazole; organic phosphines (phosphines in which one or more hydrogen atoms are substituted with organic groups) such as tributyl phosphine, diphenyl phosphine, and triphenyl phosphine; and tetraphenyl boron salts such as tetraphenyl phosphonium tetraphenyl borate and triphenyl phosphine tetraphenyl borate.

1025 [0119]

The resin layer forming composition (III) and the thermosetting resin film may contain only one kind or two or more kinds of the curing accelerators (C), and in a case in which the resin layer forming composition and the thermosetting resin film contain two or more kinds of the curing accelerators, a combination and a ratio thereof can be
1030 optionally selected.

[0120]

In a case in which the curing accelerator (C) is used, in the resin layer forming composition (III) and the thermosetting resin film, the amount of the curing accelerator (C) is preferably 0.01 to 10 parts by mass and is more preferably 0.1 to 5 parts by mass
1035 with respect to the content (100 parts by mass) of the thermosetting component (B). When the amount of the curing accelerator (C) is equal to or more than the lower limit value, the effects of the use of the curing accelerator (C) can be more significantly obtained. When the amount of the curing accelerator (C) is equal to or less than the upper limit value, for example, an effect of limiting a highly polar curing accelerator (C)
1040 from migrating toward the adhesion interface with adherends in the thermosetting resin film and segregating on the adhesion interface under the conditions of high temperature and high humidity becomes significant, and the reliability of packages obtained using the first protective film forming sheet further improves.

[0121]

1045 [Filler (D)]

The resin layer forming composition (III) and the thermosetting resin film may also contain a filler (D). When the thermosetting resin film contains the filler (D), the coefficient of thermal expansion of the first protective film obtained by curing the thermosetting resin film can be easily adjusted. For example, when this coefficient of thermal expansion of the first protective film is optimized for a subject on which the first protective film is to be formed, the reliability of packages obtained using the first protective film forming sheet further improves. In addition, when the thermosetting resin film contains the filler (D), it is also possible to decrease the moisture absorptivity of the first protective film or improving the heat dissipation property.

1055 [0122]

The filler (D) may be any one of an organic filler and an inorganic filler, but is preferably an inorganic filler.

Examples of preferred inorganic fillers include powder of silica, alumina, talc, calcium carbonate, titanium white, colcothar, silicon carbide, boron nitride, and the like; beads obtained by spherodizing this inorganic filler; surface-modified products of these inorganic fillers; and single crystal fibers of these inorganic fillers; glass fibers.

Among these, the inorganic filler is preferably silica or alumina.

[0123]

The resin layer forming composition (III) and the thermosetting resin film may contain only one kind or two or more kinds of the fillers (D), and in a case in which the resin layer forming composition and the thermosetting resin film contain two or more kinds of the fillers, a combination and a ratio thereof can be optionally selected.

[0124]

In the resin layer forming composition (III), the ratio of the amount of the filler

1070 (D) to the total amount of all of the components in addition to the solvent (that is, the amount of the filler (D) in the thermosetting resin film) is preferably 45% by mass or less (0 to 45% by mass). In addition, when the amount of the filler (D) is within the above range, the effect of limiting the residual of the curable resin film on the upper portion of the bump is further enhanced.

1075 [0125]

On the other hand, in a case of using the filler (D), in the resin layer forming composition (III), the ratio of the amount of the filler (D) with respect to the total amount of all of the components in addition to the solvent (that is, the amount of the filler (D) in the thermosetting resin film) is more preferably 5% to 45% by mass, is still more
1080 preferably 5% to 40% by mass, and is particularly preferably 10% to 30% by mass. When the amount of the filler (D) is within the above range, the effect of limiting the residual of the curable resin film on the upper portion of the bump becomes higher, and the coefficient of thermal expansion is easily adjusted.

[0126]

1085 [Coupling Agent (E)]

The resin layer forming composition (III) and the thermosetting resin film may contain a coupling agent (E). When a coupling agent having a functional group capable of reacting with an inorganic compound or an organic compound is used as the coupling agent (E), it is possible to improve the adhesiveness and adhesion of the thermosetting
1090 resin film to adherends. In addition, when the coupling agent (E) is used, the first protective film obtained by curing the thermosetting resin film is not impaired in the thermal resistance and is improved in terms of the water resistance.

[0127]

The coupling agent (E) is preferably a compound having a functional group

1095 capable of reacting with the functional group in the polymer component (A), the thermosetting component (B), or the like and more preferably a silane coupling agent.

Examples of preferred silane coupling agents include

3-glycidyloxypropyltrimethoxysilane, 3-glycidyloxypropylmethyldiethoxysilane,
 3-glycidyloxypropyltriethoxysilane, 3-glycidyloxymethyldiethoxysilane,
 1100 2-(3,4-epoxycyclohexyl)ethyltrimethoxysilane,
 3-methacryloyloxypropyltrimethoxysilane, 3-aminopropyltrimethoxysilane,
 3-(2-aminoethylamino)propyltrimethoxysilane,
 3-(2-aminoethylamino)propylmethyldiethoxysilane,
 3-(phenylamino)propyltrimethoxysilane, 3-anilinopropyltrimethoxysilane,
 1105 3-ureidopropyltrimethoxysilane, 3-mercaptopropyltrimethoxysilane,
 3-mercaptopropylmethyldimethoxysilane, bis(3-triethoxysilylpropyl)tetrasulfane,
 methyltrimethoxysilane, methyltriethoxysilane, vinyltrimethoxysilane,
 vinyltriacetoxysilane, imidazolesilane, and the like.

[0128]

1110 The resin layer forming composition (III) and the thermosetting resin film may contain only one kind or two or more kinds of the coupling agents (E), and in a case in which the resin layer forming composition and the thermosetting resin film contain two or more kinds of the coupling agents, a combination and a ratio thereof can be optionally selected.

1115 [0129]

In a case where the coupling agent (E) is used, in the resin layer forming composition (III) and the thermosetting resin film, the amount of the coupling agent (E) is preferably 0.03 to 20 parts by mass, more preferably 0.05 to 10 parts by mass, and particularly preferably 0.1 to 5 parts by mass of the total content (100 parts by mass of

1120 the polymer component (A) and the thermosetting component (B)). When the amount
of the coupling agent (E) is equal to or more than the lower limit value, the effects of the
use of the coupling agent (E) such as the improvement of the dispersibility of the filler
(D) in resins and the improvement of the adhesiveness of the thermosetting resin film to
adherends can be significantly obtained. In addition, when the amount of the coupling
1125 agent (E) is equal to or less than the upper limit value, the generation of outgas is further
limited.

[0130]

[Crosslinking Agent (F)]

In a case in which a polymer component having a functional group such as a
1130 vinyl group, a (meth)acryloyl group, an amino group, a hydroxyl group, a carboxy group,
or an isocyanate group which is capable of bonding with other compounds is used as the
polymer component (A), the resin layer forming composition (III) and the thermosetting
resin film may also contain a crosslinking agent (F). The crosslinking agent (F) is a
component for crosslinking the functional group in the polymer component (A) by
1135 bonding with the other compound, and the initial adhesive force and the agglomerative
force of the thermosetting resin film can be adjusted by crosslinking in this way.

[0131]

Examples of the crosslinking agent (F) include organic polyhydric isocyanate
compounds, organic polyhydric imine compounds, metal chelate-based crosslinking
1140 agents (crosslinking agents having a metal chelate structure), aziridine-based crosslinking
agents (crosslinking agents having an aziridinyl group), and the like.

[0132]

Examples of the organic polyhydric isocyanate compounds include aromatic
polyhydric isocyanate compounds, aliphatic polyhydric isocyanate compounds, and

1145 alicyclic polyhydric isocyanate compounds (hereinafter, in some cases, these compounds will be collectively abbreviated as “aromatic polyhydric isocyanate compounds and the like”); trimers of aromatic polyhydric isocyanate compounds and the like, isocyanurate bodies, and adduct bodies of the aromatic polyhydric isocyanate compounds and the like; terminal isocyanate urethane prepolymers obtained by reacting the aromatic polyhydric
 1150 isocyanate compounds and the like and a polyol compound. The “adduct body” refers to a reactant of the aromatic polyhydric isocyanate compound, the aliphatic polyhydric isocyanate compound, or the alicyclic polyhydric isocyanate compound and a low-molecular-weight active hydrogen-containing compound such as ethylene glycol, propylene glycol, neopentyl glycol, trimethylolpropane, or castor oil. Examples of the
 1155 adduct body include xylylene diisocyanate adducts of trimethylolpropane as described below. In addition, “the terminal isocyanate urethane prepolymer” is as described above.

[0133]

More specific examples of the organic polyhydric isocyanate compound include

1160 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;
 1165 compounds obtained by adding any one or more kinds of tolylene diisocyanate, hexamethylene diisocyanate, and xylylene diisocyanate to all or some of hydroxyl groups in a polyol such as trimethylolpropane; lysine diisocyanate; and the like.

[0134]

Examples of the organic polyhydric imine compounds include

1170 N,N'-diphenylmethane-4,4'-bis(1-aziridinecarboxamide), trimethylolpropane
tri- β -aziridinypropionate, tetramethylolmethane-tri- β -aziridinypropionate,
N,N'-toluene-2,4-bis(1-aziridinecarboxamide) triethylene melamine, and the like.

[0135]

In a case in which the organic polyhydric isocyanate compound is used as the
1175 crosslinking agent (F), a hydroxyl group-containing polymer is preferably used as the
polymer component (A). In a case in which the crosslinking agent (F) has an isocyanate
group and the polymer component (A) has a hydroxyl group, it is possible to simply
introduce a crosslinking structure into the thermosetting resin film by a reaction between
the crosslinking agent (F) and the polymer component (A).

1180 [0136]

The resin layer forming composition (III) and the thermosetting resin film may
contain only one kind or two or more kinds of the crosslinking agents (F), and in a case
in which the resin layer forming composition and the thermosetting resin film contain
two or more kinds of the crosslinking agents, a combination and a ratio thereof can be
1185 optionally selected.

[0137]

In a case in which the crosslinking agent (F) is used, the amount of the
crosslinking agent (F) in the resin layer forming composition (III) is preferably 0.01 to 20
parts by mass, more preferably 0.1 to 10 parts by mass, and particularly preferably 0.5 to
1190 5 parts by mass of the content (100 parts by mass) of the polymer component (A).

When the amount of the crosslinking agent (F) is equal to or more than the lower limit
value, the effects of the use of the crosslinking agent (F) can be significantly obtained.
In addition, when the amount of the crosslinking agent (F) is equal to or less than the
upper limit value, the excess use of the crosslinking agent (F) is limited.

1195 [0138]

[Other Components]

The resin layer forming composition (III) and the thermosetting resin film may also contain other components in addition to the above-described polymer component (A), the thermosetting component (B), the curing accelerator (C), the filler (D), the
1200 coupling agent (E), and the crosslinking agent (F), as long as the effects of the present invention are not impaired.

Examples of the above other components include an energy ray-curable resin, a photopolymerization initiator, and a versatile additive. The versatile additive may be a well-known versatile additive, can be optionally selected depending on the purpose, and
1205 is not particularly limited, and examples of preferred versatile additives include a plasticizer, an antistatic agent, an antioxidant, a colorant (a pigment or a dye), a gettering agent, and the like.

[0139]

The resin layer forming composition (III) and the thermosetting resin film may
1210 contain only one kind or two or more kinds of the above other components, and in a case in which the resin layer forming composition and the thermosetting resin film contain two or more kinds of the above other components, a combination and a ratio thereof can be optionally selected.

The amount of the above other components of the resin layer forming
1215 composition (III) and the thermosetting resin film is not particularly limited and may be appropriately selected depending on the purpose.

[0140]

[Solvent]

The resin layer forming composition (III) preferably further contains a solvent.

1220 The resin layer forming composition (III) containing a solvent improves in terms of the handling property.

The solvent is not particularly limited, but preferred examples thereof include hydrocarbons such as toluene and xylene; alcohols such as methanol, ethanol, 2-propanol, isobutyl alcohol (2-methyl propane-1-ol), and 1-butanol; esters such as ethyl acetate; 1225 ketones such as acetone and methyl ethyl ketone; ethers such as tetrahydrofuran; amides (compounds having an amide bond) such as dimethyl formamide and N-methyl pyrrolidone, and the like.

The resin layer forming composition (III) may contain only one kind or two or more kinds of the solvents, and in a case in which the resin layer forming composition 1230 contains two or more kinds of the solvents, the combination and ratio thereof can be optionally selected.

[0141]

The solvent contained in the resin layer forming composition (III) is preferably methyl ethyl ketone or the like since it is possible to more uniformly mix the components 1235 contained in the resin layer forming composition (III).

[0142]

The amount of the solvent of the resin layer forming composition (III) is not particularly limited, and for example, it may be appropriately selected depending on the kinds of components other than the solvent.

1240 [0143]

<<Method of Manufacturing Thermosetting Resin Film Forming Composition>>

The thermosetting resin film forming composition such as the resin layer forming composition (III) can be obtained by blending respective components for constituting the thermosetting resin film forming composition.

1245 The addition order during the blending of the respective components is not particularly limited, and two or more kinds of components may be added at the same time.

 In a case in which the solvent is used, the solvent may be used by mixing the solvent with all of the blending components other than the solvent so as to dilute these
1250 blending components in advance or may be used by mixing the solvent with the blending components without diluting all of the blending components other than the solvent in advance.

 A method for mixing the respective components during blending is not particularly limited and may be appropriately selected from well-known methods such as
1255 a method in which the components are mixed together by rotating a stirring stick, a stirring blade, or the like; a method in which the components are mixed together using a mixer, and a method in which the components are mixed together by applying ultrasonic waves thereto.

 The temperature and the time during the addition and mixing of the respective
1260 components are not particularly limited as long as the respective blending components do not deteriorate and may be appropriately adjusted, but the temperature is preferably 15°C to 30°C.

[0144]

◆ Energy Ray-Curable Resin Film

1265 The energy ray-curable resin film contains an energy ray-curable component (a).

 In the energy ray-curable resin film, the energy ray-curable component (a) is preferably uncured and is preferably pressure-sensitive adhesive and more preferably uncured and pressure-sensitive adhesive.

[0145]

1270 The energy ray-curable resin film may be a single layer (monolayer) or a plurality of layers of two or more layers, and in a case in which the energy ray-curable resin film is a plurality of layers, the respective layers in the plurality of layers may be identical to or different from one another, and the combination of the plurality of layers is not particularly limited.

1275 [0146]

 The thickness of the energy ray-curable resin film is preferably 1 to 100 μm , more preferably 5 to 75 μm , and particularly preferably 5 to 50 μm . When the thickness of the energy ray-curable resin film is equal to or more than the lower limit value, it is possible to form a first protective film having a higher protection function.

1280 In addition, when the thickness of the energy ray-curable resin film is equal to or less than the upper limit value, excessive thickness is limited.

 Here, “the thickness of the energy ray-curable resin film” refers to the thickness of the entire energy ray-curable resin films, and, for example, the thickness of the energy ray-curable resin film made up of a plurality of layers refers to the total thickness of all of the layers constituting the energy ray-curable resin film.

1285

 [0147]

 The curing condition when the energy ray-curable resin film is attached to the bump-formed surface of the semiconductor wafer, and is cured so as to form the first protective film is not particularly limited as long as the first protective film is cured so as to sufficiently exert its function, and may be appropriately selected according to the kinds of the thermosetting resin films.

1290

 For example, it is preferable that the illuminance of the energy ray during the curing of the energy ray-curable resin film is 180 to 280 mW/cm^2 . In addition, it is preferable that the light intensity of the energy ray during the curing is 450 to 1,000

1295 mJ/cm².

[0148]

<<Energy ray-curable resin film forming composition>>

The energy ray-curable resin film can be formed using an energy ray-curable resin film forming composition containing a constituent material thereof. For example,
1300 the energy ray-curable resin film can be formed at an intended portion by applying an energy ray-curable resin film forming composition to a target surface on which the energy ray-curable resin film is to be formed and drying the energy ray-curable resin film forming composition as necessary. The ratio between the amounts of components, which do not gasify at normal temperature, in the energy ray-curable resin film forming
1305 composition is, generally, identical to the ratio between the amounts of the above-described components in the energy ray-curable resin film.

[0149]

The energy ray-curable resin film forming composition may be applied using a well-known method, and examples thereof include methods in which a variety of coaters
1310 such as an air knife coater, a blade coater, a bar coater, a gravure coater, a roll coater, a roll knife coater, a curtain coater, a die coater, a knife coater, a screen coater, a Mayer bar coater, and a kiss coater are used.

[0150]

The drying conditions of the energy ray-curable resin film forming composition
1315 are not particularly limited; however, in a case in which the energy ray-curable resin film forming composition contains a solvent described below, the energy ray-curable resin film forming composition is preferably heated and dried. The energy ray-curable resin film forming composition containing a solvent is preferably dried at 70°C to 130°C for 10 seconds to 5 minutes.

1320 [0151]

<Resin Layer Forming Composition (IV)>

Examples of the energy ray-curable resin film forming composition include an energy ray-curable resin film forming composition (IV) containing the energy ray-curable component (a) (in the present specification, in some cases, abbreviated as “the resin layer forming composition (IV)”) and the like.

[0152]

[Energy Ray-Curable Component (a)]

The energy ray-curable component (a) is a component that is cured by irradiation with energy rays and is a component for imparting a film-forming property, flexibility, and the like to the energy ray-curable resin film.

Examples of the energy ray-curable component (a) include a polymer (a1) which has an energy ray-curable group and a weight-average molecular weight of 80,000 to 2,000,000 and a compound (a2) which has an energy ray-curable group and a molecular weight of 100 to 80,000. The polymer (a1) may be a polymer at least a part of which is crosslinked using a crosslinking agent or a polymer which is not crosslinked.

[0153]

(Polymer Having Energy Ray-Curable Group and weight-average molecular weight of 80,000 to 2,000,000 (a1))

Examples of the polymer (a1) which has an energy ray-curable group and a weight-average molecular weight of 80,000 to 2,000,000 include an acrylic resin (a1-1) formed by polymerizing an acrylic polymer (a11) having a functional group capable of reacting with groups in other compounds and an energy ray-curable compound (a12) having a group that reacts with the functional group and an energy ray-curable group such as an energy ray-curable double bond.

1345 [0154]

Examples of the functional group capable of reacting with groups in other compounds include a hydroxyl group, a carboxy group, an amino group, a substituted amino group (a group formed by substituting one or two hydrogen atoms in an amino group with a group other than a hydrogen atom), an epoxy group, and the like. Here, 1350 the functional group is preferably a group other than a carboxy group from the viewpoint of preventing the corrosion of circuits such as semiconductor wafers or semiconductor chips.

Among these, the functional group is preferably a hydroxyl group.

[0155]

1355 · Acrylic Polymer Having Functional Group (a11)

Examples of the acrylic polymer (a11) having the functional group include acrylic polymers formed by copolymerizing an acrylic monomer having the above-described functional group and an acrylic monomer not having the above-described functional group, and the acrylic polymer may be an acrylic polymer 1360 formed by copolymerizing the above-described monomers and, furthermore, a monomer other than acrylic monomers (non-acrylic monomer).

In addition, the acrylic polymer (a11) may be a random copolymer or a block copolymer.

[0156]

1365 Examples of the acrylic monomer having the functional group include hydroxyl group-containing monomers, carboxy group-containing monomers, amino group-containing monomers, substituted amino group-containing monomers, epoxy group-containing monomers, and the like.

[0157]

1370 Examples of the hydroxyl group-containing monomers include hydroxyalkyl
(meth)acrylates such as hydroxymethyl (meth)acrylate, 2-hydroxyethyl (meth)acrylate,
2-hydroxypropyl (meth)acrylate, 3-hydroxypropyl (meth)acrylate, 2-hydroxybutyl
(meth)acrylate, 3-hydroxybutyl (meth)acrylate, and 4-hydroxybutyl (meth)acrylate;
non-(meth)acrylic unsaturated alcohols such as vinyl alcohol and allyl alcohol
1375 (unsaturated alcohols not having a (meth)acryloyl skeleton); and the like.

[0158]

 Examples of the carboxy group-containing monomers include ethylenic
unsaturated monocarboxylic acids (monocarboxylic acids having an ethylenic
unsaturated bond) such as (meth)acrylic acid and crotonic acid; ethylenic unsaturated
1380 dicarboxylic acids (dicarboxylic acids having an ethylenic unsaturated bond) such as
fumaric acid, itaconic acid, maleic acid, and citraconic acid; anhydrides of the ethylenic
unsaturated dicarboxylic acid; carboxyalkyl (meth)acrylates such as 2-carboxyethyl
methacrylate; and the like.

[0159]

1385 The functional group-containing acrylic monomer is preferably the hydroxyl
group-containing monomer or the carboxy group-containing monomer and more
preferably the hydroxyl group-containing monomer.

[0160]

 The acrylic polymer (a11) may be constituted of only one kind or two or more
1390 kinds of the acrylic monomers having the functional group. In a case in which the
acrylic polymer (a11) is constituted of two or more kinds of the acrylic monomers having
the functional group, the combination and ratio thereof can be optionally selected.

[0161]

 Examples of the acrylic monomer not having the functional group include alkyl

- 1395 (meth)acrylates in which an alkyl group constituting the alkyl ester has 1 to 18 carbon atoms and has a chain-like shape such as methyl (meth)acrylate, ethyl (meth)acrylate, n-propyl (meth)acrylate, isopropyl (meth)acrylate, n-butyl (meth)acrylate, isobutyl (meth)acrylate, sec-butyl (meth)acrylate, tert-butyl (meth)acrylate, pentyl (meth)acrylate, hexyl (meth)acrylate, heptyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, isooctyl
- 1400 (meth)acrylate, n-octyl (meth)acrylate, n-nonyl (meth)acrylate, isononyl (meth)acrylate, decyl (meth)acrylate, undecyl (meth)acrylate, dodecyl (meth)acrylate (lauryl (meth)acrylate), tridecyl (meth)acrylate, tetradecyl (meth)acrylate (myristyl (meth)acrylate), pentadecyl (meth)acrylate, hexadecyl (meth)acrylate (palmityl (meth)acrylate), heptadecyl (meth)acrylate, and octadecyl (meth)acrylate (stearyl
- 1405 (meth)acrylate) and the like.

[0162]

- In addition, examples of the acrylic monomer not having the functional group also include alkoxyalkyl group-containing (meth)acrylic acid esters such as methoxymethyl (meth)acrylate, methoxyethyl (meth)acrylate, ethoxymethyl
- 1410 (meth)acrylate, and ethoxyethyl (meth)acrylate; (meth)acrylic acid esters having an aromatic group which includes (meth)acrylic acid aryl ester such as phenyl (meth)acrylate or the like; non-crosslinkable (meth)acrylamides and derivatives thereof; (meth)acrylic acid esters having a non-crosslinkable tertiary amino group such as N,N-dimethyl aminoethyl (meth)acrylate and N,N-dimethyl aminopropyl (meth)acrylate;
- 1415 and the like.

[0163]

The acrylic polymer (a11) may be constituted of only one kind or two or more kinds of the acrylic monomers not having the functional group, and in a case in which the acrylic polymer is constituted of two or more kinds of the acrylic monomers not having

1420 the functional group, the combination and ratio thereof can be optionally selected.

[0164]

Examples of the non-acrylic monomer include olefins such as ethylene and norbornene; vinyl acetate; styrene; and the like.

The acrylic polymer (a11) may be constituted of only one kind or two or more
1425 kinds of the non-acrylic monomers, and in a case in which the acrylic polymer is constituted of two or more kinds of the non-acrylic monomers, the combination and ratio thereof can be optionally selected.

[0165]

The ratio (content) of a constituent unit derived from the acrylic monomer
1430 having the functional group to the entire mass of constituent units constituting the acrylic polymer (a11) is preferably 0.1% to 50% by mass, more preferably 1% to 40% by mass, and particularly preferably 3% to 30% by mass. When the ratio is in the above-described range, in the acrylic resin (a1-1) obtained by polymerization between the acrylic polymer (a11) and the energy ray-curable compound (a12), it becomes
1435 possible to easily adjust amount of the energy ray-curable group so as to adjust the degree of curing of the first protective film to be within a preferred range.

[0166]

The acrylic polymer (a11) may be constituted of only one kind or two or more
1440 kinds of the acrylic resins (a1-1), and in a case in which the acrylic polymer is constituted of two or more kinds of the acrylic resins, the combination and ratio thereof can be optionally selected.

[0167]

In the resin layer forming composition (IV), the amount of the acrylic resin

1445 (a1-1) is preferably 1 to 40, more preferably 2 to 30, and particularly preferably 3 to 20.

[0168]

· Energy Ray-Curable Compound (a12)

The energy ray-curable compound (a12) is preferably an energy ray-curable compound having one or more kinds of groups selected from the group consisting of an isocyanate group, an epoxy group, and a carboxy group as the group capable of reacting with the functional group in the acrylic polymer (a11) and more preferably an energy ray-curable compound having an isocyanate group as the above-described group. For example, in a case in which the energy ray-curable compound (a12) has an isocyanate group as the above-described group, this isocyanate group easily reacts with a hydroxyl group in the acrylic polymer (a11) having the hydroxyl group as the functional group.

[0169]

The number of the energy ray-curable groups in one molecule of the energy ray-curable compound (a12) is preferably 1 to 5 and more preferably 1 or 2.

[0170]

1460 Examples of the energy ray-curable compound (a12) include 2-methacryloyloxyethyl isocyanate, methaisopropenyl- α,α -dimethylbenzyl isocyanate, methacryloyl isocyanate, allyl isocyanate, 1,1-(bisacryloyloxymethyl)ethyl isocyanate; acryloyl monoisocyanate compounds obtained by a reaction between a diisocyanate compound or a polyisocyanate compound and hydroxyethyl (meth)acrylate; and acryloyl monoisocyanate compounds obtained from a reaction among a diisocyanate compound or a polyisocyanate compound, a polyol compound, and hydroxyethyl (meth)acrylate; and the like.

Among these, the energy ray-curable compound (a12) is preferably 2-methacryloyloxyethyl isocyanate.

1470 [0171]

The energy ray-curable compound (a12) may be constituted of only one kind or two or more kinds of the acrylic resins (a1-1), and in a case in which the energy ray-curable compound is constituted of two or more kinds of the acrylic resins, the combination and ratio thereof can be optionally selected.

1475 [0172]

The ratio of the amount of an energy ray-curable group derived from the energy ray-curable compound (a12) to the amount of the functional group derived from the acrylic polymer (a11) in the acrylic resin (a1-1) is preferably 20 to 120 mol%, more preferably 35 to 100 mol%, and particularly preferably 50 to 100 mol%. When the ratio of the content is in the above-described range, the adhesive force of the first protective film becomes stronger. Meanwhile, in a case in which the energy ray-curable compound (a12) is a monofunctional compound (having one group in one molecule), the upper limit value of the ratio of the content becomes 100 mol%; however, in a case in which the energy ray-curable compound (a12) is a polyfunctional compound (having two or more groups in one molecule), the upper limit value of the ratio of the content exceeds 100 mol% in some cases.

[0173]

The weight-average molecular weight (Mw) of the polymer (a1) is preferably 100,000 to 2,000,000 and more preferably 300,000 to 1,500,000.

1490 Here, “the weight-average molecular weight” is as described above.

[0174]

In a case in which at least a part of the polymer (a1) is crosslinked with a crosslinking agent, the polymer (a1) may be a polymer that is formed by polymerizing monomers which do not correspond to any of the monomers described above as the

1495 monomers constituting the acrylic polymer (a11) and have a group that reacts with the crosslinking agent and is crosslinked in the group that reacts with the crosslinking agent or may be a polymer crosslinked in a group which is derived from the energy ray-curable compound (a12) and reacts with the functional group.

[0175]

1500 The resin layer forming composition (IV) and the energy ray-curable resin film may contain only one kind or two or more kinds of the polymers (a1), and in a case in which the resin layer forming composition and the energy ray-curable resin film contain two or more kinds of the polymers, the combination and ratio thereof can be optionally selected.

1505 [0176]

(Compound (a2) Having Energy Ray-Curable Group and Molecular Weight of 100 to 80,000)

Examples of the energy ray-curable group in the compound (a2) which has an energy ray-curable group and a molecular weight of 100 to 80,000 include groups having
1510 an energy ray-curable double bond, and preferred examples thereof include a (meth)acryloyl group, a vinyl group, and the like.

[0177]

The compound (a2) is not particularly limited as long as the compound satisfies the above-described conditions, and examples thereof include low-molecular-weight
1515 compounds having an energy ray-curable group, epoxy resins having an energy ray-curable group, phenolic resins having an energy ray-curable group, and the like.

[0178]

Among the compound (a2), examples of the low-molecular-weight compounds having an energy ray-curable group include polyfunctional monomers, oligomers, and

1520 the like, and acrylate compounds having a (meth)acryloyl group are preferred.

Examples of the acrylate compounds include difunctional (meth)acrylates such as 2-hydroxy-3-(meth)acryloyloxypropoyl methacrylate, polyethylene glycol di(meth)acrylate, propoxylated ethoxylated bisphenol A di(meth)acrylate, 2,2-bis[4-((meth)acryloxypolyethoxy)phenyl]propane, ethoxylated bisphenol A

1525 di(meth)acrylate, 2,2-bis[4-((meth)acryloxydiethoxy)phenyl]propane, 9,9-bis[4-(2-(meth)acryloyloxyethoxy)phenyl]fluorene, 2,2-bis[4-((meth)acryloxypolypropoxy)phenyl]propane, tricyclodecanedimethanol di(meth)acrylate, 1,10-decanediol di(meth)acrylate, 1,6-hexanediol di(meth)acrylate, 1,9-nonanediol di(meth)acrylate, dipropylene glycol di(meth)acrylate, tripropylene glycol

1530 di(meth)acrylate, polypropylene glycol di(meth)acrylate, polytetramethylene glycol di(meth)acrylate, ethylene glycol di(meth)acrylate, diethylene glycol di(meth)acrylate, triethylene glycol di(meth)acrylate, 2,2-bis[4-((meth)acryloylethoxy)phenyl]propane, neopentyl glycol di(meth)acrylate, ethoxylated polypropylene glycol di(meth)acrylate, and 2-hydroxy-1,3-di(meth)acryloxypropane; polyfunctional (meth)acrylates such as

1535 tris(2-(meth)acryloxyethyl) isocyanurate, ϵ -caprolacton-modified tris-(2-(meth)acryloxyethyl) isocyanurate, ethoxylated glycerin tri(meth)acrylate, pentaerythritol tri(meth)acrylate, trimethylolpropane tri(meth)acrylate, ditrimethylolpropane tetra(meth)acrylate, ethoxylated pentaerythritol tetra(meth)acrylate, pentaerythritol tetra(meth)acrylate, dipentaerythritol poly(meth)acrylate, and

1540 dipentaerythritol hexa(meth)acrylate; polyfunctional (meth)acrylate oligomers such as urethane (meth)acrylate oligomers; and the like.

[0179]

Among the compound (a2), as the epoxy resins having an energy ray-curable group, the phenolic resins having an energy ray-curable group, for example, the epoxy

1545 resins described in Paragraph 0043 and the like of “Japanese Unexamined Patent
Application, First Publication No. 2013-194102” can be used. These resins also
correspond to resins constituting a thermosetting component described below; however,
in the present invention, the resins will be handled as the compound (a2).

[0180]

1550 The weight-average molecular weight of the compound (a2) is preferably 100 to
30,000 and more preferably 300 to 10,000.

[0181]

The resin layer forming composition (IV) and the energy ray-curable resin film
may contain only one kind or two or more kinds of the compounds (a2), and in a case in
1555 which the resin layer forming composition and the energy ray-curable resin film contain
two or more kinds of the compounds, the combination and ratio thereof can be optionally
selected.

[0182]

[Polymer (b) Not Having Energy Ray-Curable Group]

1560 In the case of containing the compound (a2) as the energy ray-curable
component (a), the resin layer forming composition (IV) and the energy ray-curable resin
film preferably further contain a polymer (b) not having any energy ray-curable groups.

The polymer (b) may be a polymer at least a part of which is crosslinked with a
crosslinking agent or a polymer which is not crosslinked.

1565 [0183]

Examples of the polymer (b) not having any energy ray-curable group include
acrylic polymers, phenoxy resins, urethane resins, polyesters, rubber-based resins, acrylic
urethane resins, and the like.

Among these, the polymer (b) is preferably an acrylic polymer (hereinafter, in

1570 some cases, abbreviated as “the acrylic polymer (b-1)”).

[0184]

The acrylic polymer (b-1) may be a well-known acrylic polymer, and, for example, the acrylic polymer may be a homopolymer of one kind of acrylic monomer, a copolymer of two or more kinds of acrylic monomers, or a copolymer of one or more
1575 kinds of acrylic monomers and one or more kinds of monomers other than acrylic monomers (non-acrylic monomers).

[0185]

Examples of the acrylic monomer constituting the acrylic polymer (b-1) include alkyl (meth)acrylates, (meth)acrylic acid ester having a cyclic skeleton, glycidyl
1580 group-containing (meth)acrylic acid ester, hydroxyl group-containing (meth)acrylic acid esters, and substituted amino group-containing (meth)acrylic acid esters. Here, “substituted amino group” is as described above.

[0186]

Examples of the alkyl (meth)acrylates include alkyl (meth)acrylates in which an
1585 alkyl group constituting the alkyl ester has 1 to 18 carbon atoms and has a chain-like shape such as methyl (meth)acrylate, ethyl (meth)acrylate, n-propyl (meth)acrylate, isopropyl (meth)acrylate, n-butyl (meth)acrylate, isobutyl (meth)acrylate, sec-butyl (meth)acrylate, tert-butyl (meth)acrylate, pentyl (meth)acrylate, hexyl (meth)acrylate, heptyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, isooctyl (meth)acrylate, n-octyl
1590 (meth)acrylate, n-nonyl (meth)acrylate, isononyl (meth)acrylate, decyl (meth)acrylate, undecyl (meth)acrylate, dodecyl (meth)acrylate (lauryl (meth)acrylate), tridecyl (meth)acrylate, tetradecyl (meth)acrylate (myristyl (meth)acrylate), pentadecyl (meth)acrylate, hexadecyl (meth)acrylate (palmityl (meth)acrylate), heptadecyl (meth)acrylate, and octadecyl (meth)acrylate (stearyl (meth)acrylate) and the like.

1595 [0187]

Examples of the (meth)acrylic acid esters having a cyclic skeleton include cycloalkyl (meth)acrylic acid esters such as isobornyl (meth)acrylate and dicyclopentanyl (meth)acrylate; aralkyl (meth)acrylic acid esters such as benzyl (meth)acrylate; cycloalkenyl (meth) acrylic acid esters such as dicyclopentenyl (meth) acrylic acid esters; 1600 cycloalkenyloxy alkyl (meth) acrylic acid esters such as dicyclopentenylloxyethyl (meth) acrylic acid esters; and the like.

[0188]

Examples of the glycidyl group-containing (meth)acrylic acid esters include glycidyl (meth)acrylate and the like.

1605 Examples of the hydroxyl group-containing (meth)acrylic acid esters include hydroxymethyl (meth)acrylate, 2-hydroxyethyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate, 3-hydroxypropyl (meth)acrylate, 2-hydroxybutyl (meth)acrylate, 3-hydroxybutyl (meth)acrylate, 4-hydroxybutyl (meth)acrylate, and the like.

Examples of the substituted amino group-containing (meth)acrylic acid esters 1610 include N-methylaminoethyl (meth)acrylate and the like.

[0189]

Examples of the non-acrylic monomer constituting the acrylic polymer (b-1) include olefins such as ethylene and norbornene; vinyl acetate; styrene; and the like.

[0190]

1615 Examples of the polymer (b) at least a part of which is crosslinked with a crosslinking agent and which does not have the energy ray-curable group include polymers in which a reactive functional group in the polymer (b) reacts with a crosslinking agent.

The reactive functional group may be appropriately selected depending on the

1620 kind and the like of the crosslinking agent and is not particularly limited. For example,
in a case in which the crosslinking agent is a polyisocyanate compound, examples of the
reactive functional group include a hydroxyl group, a carboxy group, an amino group,
and the like, and, among these, the hydroxyl group that is highly reactive with isocyanate
groups is preferred. In addition, in a case in which the crosslinking agent is an
1625 epoxy-based compound, examples of the reactive functional group include a carboxy
group, an amino group, an amide group, and the like, and, among these, the carboxy
group that is highly reactive with epoxy groups is preferred. Here, the reactive
functional group is preferably a group other than a carboxy group from the viewpoint of
preventing the corrosion of circuits such as semiconductor wafers or semiconductor
1630 chips.

[0191]

Examples of the polymer (b) which has the reactive functional group but does
not have any energy ray-curable groups include polymers obtained by polymerizing
monomers having at least the reactive functional group. In the case of the acrylic
1635 polymer (b-1), as any one or both of the acrylic monomer and the non-acrylic monomer
that have been exemplified as the monomers constituting the acrylic polymer, monomers
having the reactive functional group may be used. For example, examples of the
polymer (b) having a hydroxyl group as the reactive functional group include polymers
obtained by polymerizing hydroxyl group-containing (meth)acrylic acid ester and also
1640 include polymers obtained by polymerizing monomers formed by substituting one or
more hydrogen atoms in the previously exemplified acrylic monomer or non-acrylic
monomer with the reactive functional group.

[0192]

In the polymer (b) having the reactive functional group, the ratio (content) of the

1645 amount of a constituent unit derived from a monomer having the reactive functional group is preferably 1 to 20% by mass and more preferably 2 to 10% by mass of the entire mass of constituent units constituting the polymer. When the ratio is in the above-described range, in the polymer (b), the degree of crosslinking is in a more preferred range.

1650 [0193]

The weight-average molecular weight (M_w) of the polymer (b) not having any energy ray-curable groups is preferably 10,000 to 2,000,000 and more preferably 100,000 to 1,500,000 since the film-forming property of the resin layer forming composition (IV) becomes more preferable. Here, “the weight-average molecular weight” is as described
1655 above.

[0194]

The resin layer forming composition (IV) and the energy ray-curable resin film may contain only one kind or two or more kinds of the polymers (b) not having any energy ray-curable groups, and, in a case in which the resin layer forming composition
1660 and the energy ray-curable resin film contain two or more kinds of the polymers not having any energy ray-curable groups, the combination and ratio thereof can be optionally selected.

[0195]

Examples of the resin layer forming composition (IV) include compositions
1665 containing any one or both of the polymer (a1) and the compound (a2). In a case of containing the compound (a2), the resin layer forming composition (IV) preferably further contains a polymer (b) not having an energy ray-curable group, and in this case, the polymer (a1) is further preferably contained. In addition, the resin layer forming composition (IV) may contain the polymer (a1) and the polymer (b) not having any

1670 energy ray-curable groups without containing the compound (a2).

[0196]

In a case where the resin layer forming composition (IV) contains the polymer (a1), the compound (a2), and the polymer (b) not having any energy ray-curable groups, in the resin layer forming composition (IV), the amount of the compound (a2) is

1675 preferably 10 to 400 parts by mass, and more preferably 30 to 350 parts by mass of the total content (100 parts by mass) of the polymer (a1) and the polymer (b) not having any energy ray-curable groups.

[0197]

In the resin layer forming composition (IV), the ratio of the total amount of the energy ray-curable component (a) and the polymer (b) not having any energy ray-curable groups (that is, the total amount of the energy ray-curable component (a) and the polymer (b) not having any energy ray-curable groups in the energy ray-curable resin film) to the total amount of the components other than the solvent is preferably 5% to 90% by mass, more preferably 10% to 80% by mass, and particularly preferably 20% to 70% by mass.

1685 When the ratio of the amount of the energy ray-curable component is in the above-described range, the energy ray-curing property of the energy ray-curable resin film becomes more preferably.

[0198]

The resin layer forming composition (IV) may also contain, in addition to the energy ray-curable component, one or more kinds of elements selected from the group consisting of a thermosetting component, a photopolymerization initiator, a filler, a coupling agent, a crosslinking agent, and a versatile additive depending on the purpose. For example, when the energy ray-curable resin composition (IV) containing the energy ray-curable component and a thermosetting component is used, the adhesive force of the

1695 energy ray-curable resin film to be formed to adherends improves by heating, and the strength of the first protective film formed of this energy ray-curable resin film also improves.

[0199]

As the thermosetting component, the photopolymerization initiator, the filler, the
1700 coupling agent, the crosslinking agent, and the versatile additive in the resin layer forming composition (IV), it is possible to exemplify those which are the same as the thermosetting component (B), the photopolymerization initiator, the filler (D), the coupling agent (E), the crosslinking agent (F), and the versatile additive in the resin layer forming composition (III).

1705 [0200]

In the resin layer forming composition (IV), one kind of each of the thermosetting component, the photopolymerization initiator, the filler, the coupling agent, the crosslinking agent, and the versatile additive may be used singly or two or more kinds thereof may be jointly used, and in a case in which two or more kinds thereof are used,
1710 the combination and ratio thereof can be optionally selected.

The amounts of the thermosetting component, the photopolymerization initiator, the filler, the coupling agent, the crosslinking agent, and the versatile additive in the resin layer forming composition (IV) may be appropriately adjusted depending on the purpose and are not particularly limited.

1715 [0201]

From the view point that the handling property of the resin layer forming composition (IV) improves by dilution, it is preferable that the resin layer forming composition (IV) further contains a solvent.

Examples of the solvent contained in the resin layer forming composition (IV)

1720 include the same solvent as that in the resin layer forming composition (III).

The resin layer forming composition (IV) may contain only one kind or two or more kinds of the solvents.

[0202]

<<Method of Manufacturing of Energy Ray-Curable Resin Film Forming

1725 Composition>>

The energy ray-curable resin film forming composition such as the resin layer forming composition (IV) can be obtained by blending individual components for constituting the energy ray-curable resin film forming composition.

The addition order during the blending of the respective components is not particularly limited, and two or more kinds of components may be added at the same time.

In a case in which the solvent is used, the solvent may be used by mixing the solvent with all of the blending components other than the solvent so as to dilute these blending components in advance or may be used by mixing the solvent with the blending components without diluting all of the blending components other than the solvent in advance.

A method for mixing the respective components during blending is not particularly limited and may be appropriately selected from well-known methods such as a method in which the components are mixed together by rotating a stirring stick, a stirring blade, or the like; a method in which the components are mixed together using a mixer, and a method in which the components are mixed together by applying ultrasonic waves thereto.

The temperature and the time during the addition and mixing of the respective components are not particularly limited as long as the respective blending components do

1745 not deteriorate and may be appropriately adjusted, but the temperature is preferably 15°C to 30°C.

[0203]

- Adhesion Layer

An adhesion layer improves adhesion between the first base member and the
1750 buffer layer, and highly limits peeling of the first base member and the buffer layer in the first protective film forming sheet. Accordingly, the first protective film forming sheet including the adhesion layer can be more stably maintained by a stacking structure of the first base member, the adhesion layer, and the buffer layer.

[0204]

1755 The adhesion layer is a sheet-form or film-form.

Examples of the preferable adhesion layer include those including an ethylene-vinyl acetate copolymer resin (EVA) or the like.

[0205]

The adhesion layer may be a single layer (monolayer) or a plurality of two or
1760 more layers. In a case in which the adhesion layer is a plurality of layers, the respective layers in the plurality of layers may be identical to or different from one another, and the combination of the plurality of layers is not particularly limited.

[0206]

The thickness of the adhesion layer is preferably 10 to 100 μm , more preferably
1765 25 to 85 μm , and particularly preferably 40 to 70 μm .

Here, “the thickness of the adhesion layer” refers to the thickness of the entire adhesion layer, and, for example, the thickness of the adhesion layer made up of a plurality of layers refers to the total thickness of all of the layers constituting the adhesion

layer.

1770 [0207]

<<Adhesion layer forming composition>>

The adhesion layer can be formed using an adhesion layer forming composition containing the constituent material thereof. For example, an adhesion layer can be formed at a target site by extruding an adhesion layer forming composition to a target surface on which the adhesion layer is to be formed. A more specific method for forming the adhesion layer will be described below in detail together with methods for forming other layers. The ratio between the amounts of components, which do not gasify at normal temperature, in the adhesion layer forming composition is, generally, identical to the ratio between the amounts of the above-described components in the adhesion layer forming composition.

[0208]

<Adhesion layer forming composition (VI)>

Examples of the adhesion layer forming composition include an adhesion layer forming composition (VI) containing an ethylene-vinyl acetate copolymer resin (EVA).

1785 [0209]

A density of the ethylene-vinyl acetate copolymer resin is preferably 1,100 kg/m³ or lower, is more preferably 850 to 1,100 kg/m³, and is particularly preferably 900 to 1,000 kg/m³. Note that, in the present specification, “density of the ethylene-vinyl acetate copolymer resin” means a value measured in accordance with JIS K 7112: 1999 unless otherwise specified.

[0210]

A melting point of the ethylene-vinyl acetate copolymer resin is preferably 50°C to 95°C, and is more preferably 65°C to 85°C.

[0211]

1795 A melt flow rate (MFR) of the ethylene-vinyl acetate copolymer resin at 190°C is preferably 1 to 10 g/10 min, and is more preferably 3 to 8 g/10 min.

 Note that, in the present specification, “melt flow rate of ethylene-vinyl acetate copolymer resin” means a value measured in accordance with JIS K 7210: 1999 unless otherwise specified.

1800 [0212]

 The amounts of the adhesion layer forming composition (VI) and ethylene-vinyl acetate copolymer resin of the adhesion layer is preferably 80% to 100% by mass.

[0213]

[Other Components]

1805 The adhesion layer forming composition (VI) and the adhesion layer may contain other components in addition to the ethylene-vinyl acetate copolymer resin as long as the effects of the present invention are not impaired.

 The above other components are not particularly limited and can be appropriately selected depending on the purpose.

1810 [0214]

 The adhesion layer forming composition (VI) and the adhesion layer may contain only one kind or two or more kinds of the above other components, and in a case in which the adhesion layer forming composition and the adhesion layer contain two or more kinds of the above other components, the combination and ratio thereof can be

1815 optionally selected.

 The amount of the above other components of the adhesion layer forming composition (VI) and the adhesion layer is not particularly limited and may be appropriately selected depending on the purpose.

[0215]

1820 ◇ Method for Manufacturing First Protective Film Forming Sheet

The first protective film forming sheet can be manufactured by sequentially stacking the respective layers described above so as to obtain the corresponding positional relationship. The methods for forming the respective layers are as described above.

1825 [0216]

For example, the first protective film forming sheet obtained by stacking the first base member, the buffer layer, and the curable resin film in this order in the thickness direction thereof can be manufactured by the following method. That is, a buffer layer is stacked on the first base member by extrusion molding the buffer layer forming composition on the first base member. In addition, the curable resin film forming composition is applied onto a peeling-treated surface of the peeling film, and the applied surface is dried as necessary so as to stack the curable resin films. Then, by attaching the curable resin film on the peeling film to the buffer layer on the first base member, the first protective film forming sheet obtained by stacking the buffer layer, the curable resin film, and the peeling film on the first base member in this order is obtained. The peeling film may be removed as necessary when using the first protective film forming sheet.

[0217]

In the above-described manufacturing method, the first protective film forming sheet provided with other layers in addition to the above-described layers can be manufactured by appropriately adding one or both of the formation step and the stacking step of the other layer so that the stacking position of the other layer is at an appropriate position.

[0218]

1845 For example, the first protective film forming sheet obtained by stacking the first
base member, the adhesion layer, the buffer layer, and the curable resin film in this order
in the thickness direction thereof can be manufactured by the following method. That is,
by co-extruding the adhesion layer forming composition and the buffer layer forming
composition on the first base member, the adhesion layer and the buffer layer are stacked
1850 in this order on the first base member. In addition, in the same method as described
above, a curable resin film is separately stacked on the peeling film. Subsequently, by
attaching the curable resin film on the peeling film to the buffer layer on the first base
member and the adhesion layer, the first protective film forming sheet obtained by
stacking the adhesion layer, the buffer layer, the curable resin film, and the peeling film
1855 on the first base member in this order is obtained. The peeling film on the curable resin
film may be removed as necessary when using the first protective film forming sheet.

[0219]

◇ Method for Using First Protective Film Forming Sheet

1860 The first protective film forming sheet of the present invention can be used as
follows.

That is, first, the first protective film forming sheet is attached to the
bump-formed surface of the semiconductor wafer using the curable resin film. At this
time, the curable resin film is attached while being heated, thereby softening the curable
resin film, and bringing the curable resin film into close contact with the bump-formed
1865 surface.

Then, as necessary, after grinding a surface (that is, a back surface) on the side
opposite to the bump-formed surface of the semiconductor wafer, a protective film
forming sheet (in the present specification, referred to as a “second protective film

forming sheet”) for protecting the back surface is attached to the back surface.

1870 Examples of the second protective film forming sheet include those provided with a second protective film forming film capable of forming the second protective film for protecting the semiconductor wafer and the back surface of the semiconductor chip by curing. The second protective film forming sheet may be formed with a dicing sheet in addition to the second protective film forming film.

1875 [0220]

Next, among the first protective film forming sheets attached to the bump-formed surface of the semiconductor wafer, only curable resin film is left on the bump-formed surface so as to peel other layers from the curable resin film. Here, “other layers to be peeled” are a first base member 11 and a buffer layer 13 in a case of a first protective film forming sheet 1 as shown in FIG. 1, and are a first base member 11, an adhesion layer 14, and a buffer layer 13 in a case of the first protective film forming sheet 2 as shown in FIG. 2.

Then, the first protective film is formed on the bump-formed surface of the semiconductor wafer by curing the curable resin film.

1885 [0221]

After that, until the manufacture of the semiconductor device can be performed by the same method as the method in the related art. That is, a semiconductor wafer having a first protective film is diced to form a semiconductor chip, and the semiconductor chip having the first protective film is picked up. The second protective film forming film may be cured at an appropriate timing according to the kinds to form a second protective film. The picked-up semiconductor chip is flip-chip mounted on a wiring substrate, and finally constitutes a semiconductor device.

[0222]

By using the first protective film forming sheet of the present invention, at a
1895 stage where this sheet is attached to the bump-formed surface of the semiconductor wafer,
at least the upper portion of the bump penetrates and protrudes through the curable resin
film and the curable resin film is prevented from remaining on the upper portion of the
bump. As a result, at least the upper portion of the bump penetrates and protrudes
through the first protective film. When such a semiconductor chip having the first
1900 protective film and the bump is flip-chip mounted on the wiring substrate, the electrical
connection between the semiconductor chip and the wiring substrate becomes excellent.

Hereinafter, the process from attaching the first protective film forming sheet of
the present invention to forming the first protective film to the bump-formed surface of
the semiconductor wafer will be described in more detail with reference to the drawings.

1905 [0223]

FIG. 3 is a cross-sectional view schematically showing an example of a method
of using the first protective film forming sheet 1 as shown in FIG. 1.

When the first protective film forming sheet 1 is used, first, as shown in FIG.
3(a), the first protective film forming sheet 1 is placed such that the curable resin film 12
1910 faces the bump-formed surface 9a of the semiconductor wafer 9.

[0224]

The height of the bump 91 is not particularly limited, but it is preferably 120 to
300 μm , more preferably 150 to 270 μm , and particularly preferably 180 to 240 μm .

When the height of the bump 91 is equal to or more than the lower limit value, a function
1915 of the bump 91 can be further improved. In addition, since the height of the bump 91 is
equal to or less than the upper limit value, the effect of limiting the residual of the
curable resin film 12 on the upper portion of the bump 91 is further enhanced.

In the present specification, “the height of the bump” means the height of the

bump at the highest position from the bump-formed surface.

1920 [0225]

Although the width of the bump 91 is not particularly limited, it is preferably 170 to 350 μm , more preferably 200 to 320 μm , and particularly preferably 230 to 290 μm . When the width of the bump 91 is equal to or more than the lower limit value, the function of the bump 91 can be further improved. In addition, since the height of the bump 91 is equal to or less than the upper limit value, the effect of limiting the residual of the curable resin film 12 on the upper portion of the bump 91 is further enhanced.

Note that, in this specification, the “width of the bump” means the maximum value of a line segment obtained by connecting two different points on the bump surface with a straight line when looking down the bump in a direction perpendicular to the bump-formed surface in a plan view.

[0226]

Although the distance between the adjacent bumps 91 is not particularly limited, it is preferably 250 to 800 μm , more preferably 300 to 600 μm , and particularly preferably 350 to 500 μm . When the distance is equal to or more than the lower limit value, the function of the bump 91 can be further improved. In addition, since the distance of the bump is equal to or less than the upper limit value, the effect of limiting the residual of the curable resin film 12 on the upper portion of the bump 91 is further enhanced.

Note that, in this specification, the “distance between adjacent bumps” means the minimum value of the distance between the surfaces of adjacent bumps.

[0227]

Next, the curable resin film 12 is brought into contact with the bump 91 on the

semiconductor wafer 9, and the first protective film forming sheet 1 is pressed against the semiconductor wafer 9. With this, the first surface 12a of the curable resin film 12 is
1945 sequentially crimped to the front surface 91a of the bump 91 and the bump-formed surface 9a of the semiconductor wafer 9. At this time, by heating the curable resin film 12, the curable resin film 12 softens, spreads between the bumps 91 so as to cover the bumps 91, closely adheres to the bump-formed surface 9a, and covers the front surface 91a of the bump 91, in particular, the front surface 91a of the vicinity of the
1950 bump-formed surface 9a, and buries into the bump 91.

As shown in FIG. 3(b), the curable resin film 12 of the first protective film forming sheet 1 is attached to the bump-formed surface 9a of the semiconductor wafer 9.

[0228]

As described above, as a method of crimping the first protective film forming
1955 sheet 1 to the semiconductor wafer 9, a known method of crimping and attaching various sheets to a target can be applied. For example, a method using a laminating roller or the like are exemplary examples.

[0229]

The heating temperature of the first protective film forming sheet 1 at the time
1960 of crimping on the semiconductor wafer 9 may be any temperature as long as the curable resin film 12 is not cured at all or excessively, and it is preferably 80°C to 100°C, and is more preferably 85°C to 95°C.

[0230]

The pressure at which the first protective film forming sheet 1 is crimped to the
1965 semiconductor wafer 9 is not particularly limited, but it is preferably 0.1 to 1.5 MPa, and is more preferably 0.3 to 1 MPa.

[0231]

When the first protective film forming sheet 1 is crimped to the semiconductor wafer 9 as described above, the curable resin film 12 and the buffer layer 13 in the first protective film forming sheet 1 are subjected to pressure from the bump 91, and the first surface 12a of the curable resin film 12 and the first surface 13a of the buffer layer 13 are deformed into a concave shape at an initial stage. Then, breakage occurs in the curable resin film 12 subjected to pressure from the bump 91 as it is. Lastly, at a stage where the first surface 12a of the curable resin film 12 is crimped to the bump-formed surface 9a of the semiconductor wafer 9, an upper portion 910 of the bump 91 penetrates and protrudes through the curable resin film 12. In this final stage, usually, the upper portion 910 of the bump 91 does not penetrate through the buffer layer 13. This is because the buffer layer 13 has a buffer action against the pressure applied from the bump 91.

[0232]

As shown in FIG. 3(b), at a stage where the first protective film forming sheet 1 is attached to the bump-formed surface 9a of the semiconductor wafer 9, the curable resin film 12 does not remain at all or does not almost remain on the upper portion 910 of the bump 91. In the present specification, “the curable resin film does not almost remain on the upper portion of the bump” means that, unless otherwise specified, although the curable resin film slightly remains on the upper portion of the bump, the remaining amount is to the extent that the electrical connection between the semiconductor chip and the wiring substrate is not hindered when the semiconductor chip having the bump is flip-chip mounted on the wiring substrate.

[0233]

As described above, in the upper portion 910 of the bump 91, the reason why the curable resin film 12 can be prevented from remaining is that when the curable resin film

12 is pressed from the bump 91 and deformed as described above, the curable resin film 12 is designed to be particularly easily broken. That is, in the first protective film forming sheet 1, since the curable resin film 12 and the buffer layer 13 satisfy the relationship of the above Expression (w1), when large distortion occurs in these (curable resin film 12 and buffer layer 13), the buffer layer 13 exhibits an appropriate buffering action and the curable resin film 12 is broken into an appropriate state.

[0234]

After attaching the first protective film forming sheet 1 to of the bump-formed surface 9a of the semiconductor wafer 9, the surface (back surface) 9b on the side opposite to the bump-formed surface 9a of the semiconductor wafer 9 is further ground as necessary, and then a second protective film forming sheet (not shown) is attached to the back surface 9b.

Then, as shown in FIG. 3(c), the first base member 11 and the buffer layer 13 are peeled from the curable resin film 12.

Then, the first protective film 12' is formed on the bump-formed surface 9a, as described above FIG. 3(d), by curing the curable resin film 12.

[0235]

Here, the case of using the first protective film forming sheet 1 as shown in FIG. 1 was described; however, also in a case of using the first protective film forming sheets of other embodiments, such as the first protective film forming sheet 2 as shown in FIG. 2, these first protective film forming sheets exhibit the same effect as that of the case of using the first protective film forming sheet 1.

[0236]

FIG. 4 is a cross-sectional view schematically showing an example of a method of using the first protective film forming sheet 2 as shown in FIG. 2.

Even when the first protective film forming sheet 2 is used, first, as shown in FIG. 4(a), the first protective film forming sheet 2 is placed such that the curable resin film 12 faces the bump-formed surface 9a of the semiconductor wafer 9.

[0237]

Next, the curable resin film 12 is brought into contact with the bump 91 on the semiconductor wafer 9 while being heated, and the first protective film forming sheet 2 is pressed against the semiconductor wafer 9. With this, the first surface 12a of the curable resin film 12 is sequentially crimped to the front surface 91a of the bump 91 and the bump-formed surface 9a of the semiconductor wafer 9. As shown in FIG. 4(b), the curable resin film 12 of the first protective film forming sheet 2 is attached to the bump-formed surface 9a of the semiconductor wafer 9.

At this time, the first protective film forming sheet 2 can be crimped to the semiconductor wafer 9 in the same method as that of the case of using the first protective film forming sheet 1.

[0238]

When the first protective film forming sheet 2 is crimped to the semiconductor wafer 9 as described above, the curable resin film 12 and the buffer layer 13 in the first protective film forming sheet 2 are subjected to pressure from the bump 91, and the first surface 12a of the curable resin film 12 and the first surface 13a of the buffer layer 13 are deformed into a concave shape at an initial stage. Then, breakage occurs in the curable resin film 12 subjected to pressure from the bump 91 as it is. Lastly, at a stage where the first surface 12a of the curable resin film 12 is crimped to the bump-formed surface 9a of the semiconductor wafer 9, an upper portion 910 of the bump 91 penetrates and protrudes through the curable resin film 12. In this final stage, usually, the upper portion 910 of the bump 91 does not pass through the buffer layer 13.

Further, when the first protective film forming sheet 2 is used, as described above, in the process in which the curable resin film 12 is attached to the bump-formed surface 9a of the semiconductor wafer 9, the adhesion layer 14 highly limits peeling of the first base member 11 and the buffer layer 13, and the stacking structure of the first base member 11, the adhesion layer 14, and the buffer layer 13 is more stably maintained.

[0239]

As shown in FIG. 4(b), at a stage where the first protective film forming sheet 2 is attached to the bump-formed surface 9a of the semiconductor wafer 9, due to the same action as that of the case of the first protective film forming sheet 1, the curable resin film 12 does not remain at all or does not almost remain on the upper portion 910 of the bump 91.

[0240]

After attaching the first protective film forming sheet 2 to of the bump-formed surface 9a of the semiconductor wafer 9, the surface (back surface) 9b on the side opposite to the bump-formed surface 9a of the semiconductor wafer 9 is further ground as necessary, and then a second protective film forming sheet (not shown) is attached to the back surface 9b.

Then, as shown in FIG. 4(c), the first base member 11, the adhesion layer 14, and the buffer layer 13 are peeled from the curable resin film 12.

Then, the first protective film 12' is formed on the bump-formed surface 9a, as described above FIG. 4(d), as described above, by curing the curable resin film 12.

[0241]

Whether or not the curable resin film or the protective film remains on the upper portion of the bump can be confirmed, for example, by acquiring the imaging data of the

SEM for the bump.

[Examples]

2070 [0242]

Hereinafter, the present invention will be more specifically described using specific examples. However, the present invention is not limited to examples described below.

[0243]

2075 The components used for manufacturing the thermosetting resin film forming composition are indicated below.

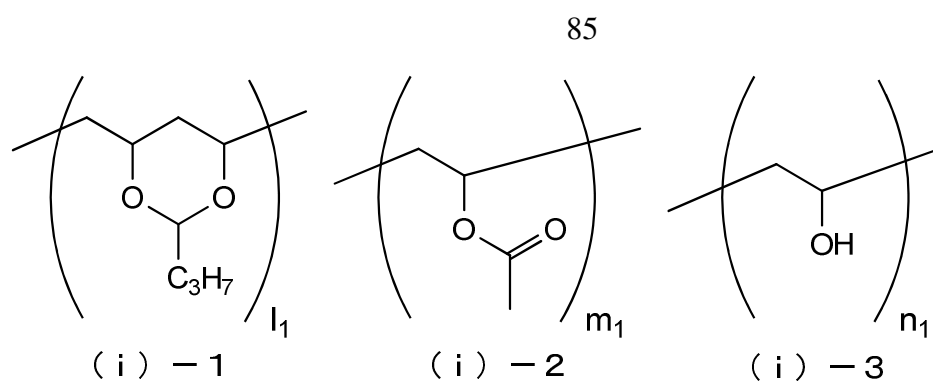
· Polymer Component

polymer component (A)-1: polyvinyl butyral having constituent units represented by Formulae (i)-1, (i)-2, and (i)-3 (“S-LEC BL-10”, Sekisui Chemical Co.,
2080 Ltd., weight-average molecular weight 25000, glass transition temperature of 59°C)

Polymer component (A)-2: An acrylic resin (a weight-average molecular weight of 800,000 and a glass transition temperature of -28°C) obtained by copolymerizing butyl acrylate (hereinafter, abbreviated as “BA”) (55 parts by mass), methyl acrylate (hereinafter, abbreviated as “MA”) (10 parts by mass), glycidyl methacrylate (hereinafter,
2085 abbreviated as “GMA”) (20 parts by mass), and 2-hydroxyethyl acrylate (hereinafter, abbreviated as “HEA”) (15 parts by mass).

[0244]

[Chem. 2]



2090 (In Formula, l_1 is about 28, m_1 is 1 to 3, and n_1 is an integer of 68 to 74.)

[0245]

· Epoxy resin

Epoxy resin (B1)-1: A liquid bisphenol F type epoxy resin (“YL 983 U”
manufactured by Mitsubishi Chemical Corporation)

2095 Epoxy resin (B1)-2: A polyfunctional aromatic type epoxy resin (“EPPN-502H”
manufactured by Nippon Kayaku Co., Ltd.)

Epoxy resin (B1)-3: A dicyclopentadiene type epoxy resin (“EPICLON
HP-7200” manufactured by DIC Corporation)

· Thermal Curing Agent

2100 Thermal curing agent (B2)-1: A novolac type phenol resin (“BRG-556”
manufactured by Showa Denko KK)

· Curing Accelerator

Curing accelerator (C)-1: 2-phenyl-4,5-dihydroxymethylimidazole (“Curezol 2
PHZ-PW” manufactured by Shikoku Chemicals Corporation)

2105 · Filler

Filler (D)-1: A spherical silica modified with an epoxy group (“Admanano YA
050 C-MKK” manufactured by Admatechs.)

[0246]

[Example 1]

2110 <Manufacturing of First Protective Film Forming Sheet>

(Manufacturing of Thermosetting Resin Film Forming Composition)

The polymer component (A)-1, the epoxy resin (B1)-1, the epoxy resin (B1)-2, the epoxy resin (B1)-3, the thermal curing agent (B2)-1, and the curing accelerator (C)-1 were dissolved and dispersed in methyl ethyl ketone such that the ratio of the content to
 2115 the total amount of all components is the value indicated in the following Table 1, and stirred at 23°C so as to obtain a resin layer forming composition (III) having the solid content concentration of 55% by mass as a thermosetting resin film composition. Note that, the description “-” in the column of contained components in the following Table 1 means that the thermosetting resin film forming composition does not contain that
 2120 component.

[0247]

(Manufacturing of First Protective Film Forming Sheet)

By co-extruding an ethylene-vinyl acetate copolymer resin (“EVAFLEX
 EV260” (registered trademark) manufactured by Du Pont-Mitsui Polychemicals Co., Ltd.,
 2125 density of 950 kg/m³, melting point of lower than 72°C, melt flow rate (190°C) of 6 g/10 min), and an ethylene- α -olefin copolymer (“TAFMR DF640” prepared by Mitsui Chemicals, Inc., density of 864 kg/m³, melting point of lower than 50°C, melt flow rate (190°C) of 3.6 g/10 min, melt flow rate (230°C) of 6.7 g/10 min) to a polyethylene terephthalate (PET) film (“LUMIRROR” (registered trademark) manufactured by Toray
 2130 Industries, Inc., thickness of 100 μ m) using a small T die extruder (“LABO PLASTOMILL” manufactured by Toyo Seiki Seisaku-sho, Ltd.), the adhesion layer made of an ethylene-vinyl acetate copolymer resin, and the buffer layer (thickness of 400 μ m) made of an ethylene- α -olefin copolymer were stacked on the first base member

made of the PET film in this order.

2135 [0248]

The above-obtained thermosetting resin film forming composition was applied onto a peeling-treated surface of a peeling film ("SP-PET381031" manufactured by Lintec Corporation, thickness: 38 μm) obtained by carrying out a peeling treatment on a single surface of a polyethylene terephthalate film with a silicone treatment and was
2140 heated and dried at 120°C for two minutes, thereby forming a 30 μm -thick thermosetting resin film.

Subsequently, by attaching the thermosetting resin film on the peeling film to the buffer layer formed on the first base member, the first protective film forming sheet, having a configuration as shown in FIG. 2, obtained by stacking the adhesion layer, the
2145 buffer layer, the thermosetting resin film, and the peeling film on the first base member in this order was obtained.

[0249]

<Evaluation of First Protective Film Forming Sheet>

(Measurement of Shear modulus G' of Buffer Layer and Thermosetting Resin Film)

2150 A buffer layer having a thickness of 1000 μm was formed in the same manner as described above except that the coating amount of the buffer layer forming composition was changed. Subsequently, this buffer layer was cut into a disk shape having a diameter of 8 mm to obtain a test piece of the buffer layer.

A thermosetting resin film having a thickness of 1000 μm was formed in the
2155 same manner as described above except that the coating amount of the thermosetting resin film forming composition was changed. Subsequently, the thermosetting resin film was cut into a disk shape having a diameter of 8 mm to obtain a test piece of the

thermosetting resin film.

2160 An installation place of the test piece of a shear viscosity measuring apparatus was kept at 90°C in advance, and the test piece of the buffer layer and the thermosetting resin film obtained above was placed on the installation place, and a measuring jig was pressed against the top surface of the test piece such that the test piece was fixedly installed at the installation place.

2165 Next, under the conditions of a temperature of 90°C and a measuring frequency of 1 Hz, the occurred distortion was increased stepwise from 0.01% to 1000%, and the shear modulus G' of the test piece at the applied distortion was measured. The results are indicated in FIG. 5. In FIG. 5, the measurement value indicated as “Example 1” is a measurement value for a test piece of a thermosetting resin film.

[0250]

2170 (Confirmation of Residual Presence of Thermosetting Resin Film at Upper Portion of Bump)

2175 The thermosetting resin film of the first protective film forming sheet obtained above was brought into contact with the bump of the semiconductor wafer, and the first protective film forming sheet was crimped to the semiconductor wafer while being heated. The semiconductor wafers in which a bump having a height of 210 μm , a bump having a width of 250 μm , and a distance between bumps of 400 μm were used. The heating temperature of the first protective film forming sheet was set to 90°C, and the pressure was set to 0.5 MPa. With this, the thermosetting resin film was attached to the bump-formed surface of the semiconductor wafer.

2180 Then, the first base member, the adhesion layer, and the buffer layer were peeled from the thermosetting resin film so as to expose the thermosetting resin film.

Subsequently, using a scanning electron microscope (SEM, “VE-9700”
manufactured by Keyence Corporation), the surface of the bump of the semiconductor
wafer was observed from the direction perpendicular to the bump-formed surface of the
semiconductor wafer and the direction forming an angle of 60°, and the residual presence
of the thermosetting resin film of the upper portion of the bump was confirmed. The
results are indicated in Table 1.

[0251]

[Examples 2 and 3 and Comparative Examples 1 and 2]

<Manufacture and Evaluation of First Protective Film Forming Sheet>

The first protective film forming sheet was produced and evaluated in the same
manner as in Example 1 except that at the time of production of the thermosetting resin
film forming composition, one or both of the kind and the content ratio of each
component were set as indicated in Table 1, and the shear modulus G' of the test piece of
the buffer layer was not measured. The results are indicated in FIG. 5 and Table 1. In
FIG. 5, the measurement values indicated as “Example 2”, “Example 3”, “Comparative
Example 1”, and “Comparative Example 2” were the same as the measurement values for
test pieces of thermosetting resin films of the examples or comparative examples.

[0252]

2200

[Table 1]

			Example			Comparative Example	
			1	2	3	1	2
Components contained in thermosetting resin film forming composition (Content (part by mass))	Polymer component	(A)- 1	100	100	-	-	-
		(A) - 2	-	-	100	100	100
	Epoxy resin	(B1) - 1	190	190	190	80	130
		(B1) - 2	130	130	130	60	90
		(B1) - 3	210	210	210	90	150
	Thermal curing agent	(B2) - 1	270	270	270	120	180
	Curing accelerator	(C) - 1	2	2	2	1	2
	Filler	(D) - 1	230	-	-	370	160
Evaluation result	Residual of curable resin film on upper portion of bump		None	None	None	Present	Present

[0253]

2205 As shown in FIG. 5, in Examples 1 to 3, the buffer layer and the thermosetting resin film are satisfied with the relationship of Expression (w1). In Examples 1 and 2, Gc300' was not able to be measured directly; however, it was obvious that the relationship of Gb300' > Gc300' was satisfied.

Further, in Examples 1 and 2, Gc200' and Gc400' were not able to be measured
2210 directly; however, it was obvious that the relationships of Gb200' > Gc200' and Gb400' > Gc400' were satisfied, and the relationship of Expressions (w2) and (w3) was also satisfied. On the other hand, in Example 3, the relationship of Expression (w2) was satisfied, but the relationship of Expression (w3) was not satisfied.

[0254]

2215 Also, as is apparent from FIG. 5, in Examples 1 to 3, in a function (function Fb) of the distortion of the buffer layer and shear modulus G' (Gb'), a region (variable region Rb) in which the shear modulus Gb' was not constant existed, and the shear modulus Gb' when the distortion of the buffer layer was 300% was included in the region (variable region Rb).

2220 Further, in Examples 1 to 3, in the function (function Fc) of the distortion of the thermosetting resin film and the shear modulus G' (Gc'), the region where the shear modulus Gc' was not constant (the variable region Rc) existed. In Examples 1 and 2, the distortion of 300% of the thermosetting resin film was not able to be observed directly, but in Example 3, the shear modulus Gc' when the distortion of the thermosetting resin film
2225 was 300% was included in the region (variable region Rc).

[0255]

In a case where the first protective film forming sheets of Examples 1 to 3 were used, from the SEM image data, it was possible to confirm that no thermosetting resin film

remained at the upper portion of the bump of the semiconductor wafer.

2230 [0256]

In contrast, as shown in FIG. 5, in Comparative Examples 1 and 2, the buffer layer and the thermosetting resin film did not satisfy the relationship of Expression (w1). On the other hand, in Comparative Examples 1 and 2, the relationship of Expression (w2) was satisfied, but the relationship of Expression (w3) was not satisfied.

2235 In a case where the first protective film forming sheets of Comparative Examples 1 and 2 were used, it was possible to confirm that the thermosetting resin film remained on the upper portion of the bump of the semiconductor wafer. In the SEM imaging data of these Comparative Examples, there was a striped pattern over the entire surface including the upper portion of the bump, and the size of the bump was obviously larger than that of
2240 the examples, and thereby it was possible to clearly confirm the residual of the thermosetting resin film on the surface of the bump. The thickness of the thermosetting resin film remaining on the upper portion of the bump was calculated from the imaging data of the SEM. As a result, it was about 9.4 μm in Comparative Example 1 and about 4.8 μm in Comparative Example 2.

2245

Industrial Applicability

[0257]

The present invention can be used for manufacturing a semiconductor chip or the like having a bump at a connection pad portion used in a flip chip mounting method.

2250

Reference Signs List

[0258]

	1, 2 ... FIRST PROTECTIVE FILM FORMING SHEET
	11 ... FIRST BASE MEMBER
2255	11a ... FIRST SURFACE OF FIRST BASE MEMBER
	12 ... CURABLE RESIN FILM
	12a ... FIRST SURFACE OF CURABLE RESIN FILM
	12' ... FIRST PROTECTIVE FILM
	13 ... BUFFER LAYER
2260	13a ... FIRST SURFACE OF BUFFER LAYER
	14 ... ADHESION LAYER
	14a ... FIRST SURFACE OF ADHESION LAYER
	9 ... SEMICONDUCTOR WAFER
	9a ... BUMP-FORMED SURFACE OF SEMICONDUCTOR WAFER
2265	91 ... BUMP
	91a ... SURFACE OF BUMP
	910 ... UPPER PORTION OF BUMP

CLAIMS

2270 What is claimed is:

1. A first protective film forming sheet comprising:

a first base member;

a buffer layer formed on the first base member; and

a curable resin film formed on the buffer layer,

2275 wherein the curable resin film is attached to a surface of a semiconductor wafer,
which has a bump, and cured so as to form a first protective film on the surface,

wherein at the time of performing a distortion dispersion measurement in which a
shear modulus G' of a test piece of the buffer layer is measured by causing a distortion to
occur on the test piece of the buffer layer having a diameter of 8 mm and a thickness of 1

2280 mm under conditions of a temperature of 90°C and a frequency of 1 Hz, the shear modulus
of the test piece of buffer layer is G_{b300}' when the distortion of the test piece of the buffer
layer is 300%,

wherein at the time of performing a distortion dispersion measurement in which a
shear modulus G' of a test piece of the curable resin film is measured by causing a

2285 distortion to occur on the test piece of the curable resin film having a diameter of 8 mm
and a thickness of 1 mm under conditions of a temperature of 90°C and a frequency of 1
Hz, the shear modulus of the test piece of the curable resin film is G_{c300}' when the
distortion of the test piece of the curable resin film is 300%, and

wherein the G_{b300}' and the G_{c300}' satisfy a relationship represented by

2290 Expression (w1): $G_{b300}' \geq G_{c300}'$.

2. The first protective film forming sheet according to Claim 1,

wherein a shear modulus G_{b200}' of the test piece of the buffer layer when the distortion of the test piece of the buffer layer is 200%, and a shear modulus G_{c200}' of the test piece of the curable resin film when the distortion of the test piece of the curable resin film is 200% satisfy a relationship represented by Expression (w2): $G_{b200}' \geq G_{c200}'$.

3. The first protective film forming sheet according to Claim 1 or 2,
wherein a shear modulus G_{b400}' of the test piece of the buffer layer when the distortion of the test piece of the buffer layer is 400%, and a shear modulus G_{c400}' of the test piece of the curable resin film when the distortion of the test piece of the curable resin film is 400% satisfy a relationship represented by Expression (w3): $G_{b400}' \geq G_{c400}'$.

4. The first protective film forming sheet according to any one of Claims 1 to 3,
wherein in a function of the distortion of the test piece of the buffer layer and the shear modulus G_b' of the test piece of the buffer layer which are obtained by the distortion dispersion measurement, a region where the shear modulus G_b' is not constant exists, and the shear modulus G_b' when the distortion of the test piece of the buffer layer is 300% is included in the region.

2310

5. The first protective film forming sheet according to any one of Claims 1 to 4,
wherein in a function of the distortion of the test piece of the curable resin film and a shear modulus G_c' of the test piece of the curable resin film which are obtained by the distortion dispersion measurement, a region where the shear modulus G_c' is not constant exists, and the shear modulus G_c' when the distortion of the test piece of the curable resin film is 300% is included in the region.

2315

6. The first protective film forming sheet according to any one of Claims 1 to 5,
wherein the curable resin film contains a resin component,
2320 wherein a amount of a filler of the curable resin film is 45% by mass or less, and
wherein a weight-average molecular weight of the resin component is 30,000 or
less.