

DESCRIPTION

TITLE OF THE INVENTION: SEPARATOR-EQUIPPED SEALING SHEET AND
SEMICONDUCTOR DEVICE PRODUCTION METHOD

TECHNICAL FIELD

[0001]

The present invention relates to a separator-equipped sealing sheet and a semiconductor device production method.

BACKGROUND ART

[0002]

As a method for manufacturing a semiconductor device, a method has been conventionally known of sealing one or more semiconductor chips fixed to a substrate, etc. with a sealing resin and dicing the sealed body to form a packaged semiconductor device unit. For example, a sealing sheet constituted with a thermosetting resin has been known as the sealing resin (for example, refer to Patent Document 1).

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0003]

Patent Document 1: JP-A-2006-19714

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0004]

Conventionally, when a semiconductor device is produced by the above-mentioned method, a semiconductor chip is buried in a sealing sheet in a state where a surface of the sealing sheet that is opposite to the semiconductor-chip-side surface of the sealing sheet is equipped with a separator. Thereafter, the separator is peeled off, and subsequently the sealing sheet is thermally cured.

[0005]

However, in the case of the production of the semiconductor device through this process, the external appearance of the semiconductor device (particularly, the surface of the sealing sheet) may be damaged.

[0006]

In light of this problem, the present invention has been made, and an object thereof is to provide a separator-equipped sealing sheet and a semiconductor device production method which can each realize a good external appearance of a semiconductor device to be produced.

MEANS FOR SOLVING THE PROBLEM

[0007]

The inventors have made eager investigations about causes for damage of the external appearance of a semiconductor device.

As a result, the inventors have found out that when a separator is peeled off from a separator-equipped sealing sheet and subsequently the sealing sheet is thermally cured, the external appearance of the thermally cured sealing sheet is damaged. The inventors have found out that if a separator-equipped sealing sheet can be thermally cured before the separator is peeled off therefrom, it is possible to realize a good external appearance of the resultant semiconductor device. The inventors have further made eager investigations to find out that when the separator has been treated with an aminoalkyd release agent, the separator can easily be peeled off from the sealing sheet after the thermal curing of the sealing sheet. In this way, the present invention has been accomplished.

[0008]

Accordingly, the present invention provides a separator-equipped sealing sheet, including:

a separator, and

a sealing sheet laminated on the separator;

wherein a surface of the separator that contacts the sealing sheet is treated with an aminoalkyd release agent.

[0009]

According to this configuration, the surface of the separator that contacts the sealing sheet is treated with the aminoalkyd release agent. Accordingly, after the sealing sheet is thermally cured, the separator can easily be peeled

off from the sealing sheet. As a result, for example, the following can be attained: the separator-equipped sealing sheet is disposed on a semiconductor chip; the semiconductor chip is then buried in the sealing sheet to form a sealed body including the semiconductor chip buried in the sealing sheet (the following step C); and the sealing sheet of the sealed body is thermally cured in the state of being equipped with the separator (the following step D). This matter makes it possible to restrain the surface of the sealing sheet from being roughened at the time of the thermal curing. Moreover, the surface of the separator that contacts the sealing sheet is treated with the aminoalkyd release agent; thus, after the thermal curing of the sealing sheet, the separator can easily be peeled off from the sealing sheet (the following step E). Since the separator can easily be peeled off from the sealing sheet even after the thermal curing, the use of the separator-equipped sealing sheet makes it possible to restrain the surface roughening to yield a semiconductor device good in external appearance.

[0010]

In this configuration, it is preferred that the separator-equipped sealing sheet has a peel strength less than 0.4 N/100 mm width, the peel strength being a peel strength between the sealing sheet and the separator each heated at 150°C for 1 hour.

[0011]

When the peel strength between the sealing sheet and the separator each heated at 150°C for 1 hour is less than 0.4 N/100 mm width, the separator can more easily be peeled off from the sealing sheet after the sealing sheet is thermally cured.

[0012]

In this configuration, the sealing sheet preferably contains an epoxy resin.

[0013]

The inventors have found out that about the separator treated with the aminoalkyd release agent and the epoxy resin-containing sealing sheet, the peel strength between these two members is low also after the members are heated. In other words, when the sealing sheet contains the epoxy resin, the peel strength between the sealing sheet and the separator can be made lower after the members are heated.

[0014]

The semiconductor device production method according to the present invention includes:

a step A of providing a stacked body including a support and a semiconductor chip fixed onto the support;

a step X of providing the above-defined separator-equipped sealing sheet;

a step B of disposing the separator-equipped sealing sheet on the semiconductor chip of the stacked body;

a step C of burying the semiconductor chip in the sealing sheet to form a sealed body including the semiconductor chip buried in the sealing sheet;

a step D of thermally curing the sealing sheet of the sealed body; and

a step E of peeling off the separator after the step D.

[0015]

According to this configuration, the separator-equipped sealing sheet is disposed on the semiconductor chip, and subsequently the semiconductor chip is buried in the sealing sheet to form the sealed body including the semiconductor chip buried in the sealing sheet (the step C). The sealing sheet of the sealed body is thermally cured in the state of being equipped with the separator (the step D). Since the sealing sheet is thermally cured in the state of being equipped with the separator, the surface of the sealing sheet can be restrained from being roughened at the time of the thermal curing of the sealing sheet. After the thermal curing, the separator is peeled off from the sealing sheet (the step E). Since the surface of the separator that contacts the sealing sheet is treated with the aminoalkyd release agent, the separator can easily be peeled off from the sealing sheet after the thermal curing of the sealing sheet. Since the separator can easily be peeled off from the sealing sheet even after the thermal curing, the surface roughening of the sealing sheet can

be restrained to yield a semiconductor device good in external appearance.

EFFECT OF THE INVENTION

[0016]

The present invention makes it possible to provide a separator-equipped sealing sheet that can realize a good external appearance of a semiconductor device to be produced therefrom.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

Fig. 1 is a schematic cross section of a separator-equipped sealing sheet according to the present embodiment.

Fig. 2 is a schematic cross section for explaining a method for manufacturing a semiconductor device according to the present embodiment.

Fig. 3 is a schematic cross section for explaining a method for manufacturing a semiconductor device according to the present embodiment.

Fig. 4 is a schematic cross section for explaining a method for manufacturing a semiconductor device according to the present embodiment.

Fig. 5 is a schematic cross section for explaining a

method for manufacturing a semiconductor device according to the present embodiment.

Fig. 6 is a schematic cross section for explaining a method for manufacturing a semiconductor device according to the present embodiment.

Fig. 7 is a schematic cross section for explaining a method for manufacturing a semiconductor device according to the present embodiment.

Fig. 8 is a schematic cross section for explaining a method for manufacturing a semiconductor device according to the present embodiment.

Fig. 9 is a schematic cross section for explaining a method for manufacturing a semiconductor device according to the present embodiment.

Fig. 10 is a schematic cross section for explaining a method for manufacturing a semiconductor device according to the present embodiment.

Fig. 11 is a schematic cross section for explaining a method for manufacturing a semiconductor device according to the present embodiment.

MODE FOR CARRYING OUT THE INVENTION

[0018]

The embodiments of the present invention will be explained below by referring the drawings. However, the

present invention is not limited to only these embodiments.

[0019]

(Separator-Equipped Sealing Sheet)

As illustrated in Fig. 1, a separator-equipped sealing sheet 10 has a structure including a separator 16 and a sealing sheet 11 laminated on the separator 16.

[0020]

(Separator)

Examples of the separator 16 include plastic films (such as a polyethylene terephthalate (PET) film, a polyethylene film, and a polypropylene film), nonwoven fabric pieces, and paper pieces. The substrate may have a single layer, or plural layers of two or more kinds.

[0021]

A surface of the separator 16 that contacts the sealing sheet 11 is treated with an aminoalkyd release agent. Thus, after the sealing sheet 11 is thermally cured, the separator 16 can easily be peeled off from the sealing sheet 11.

[0022]

The thickness of the separator 16 is not particularly limited; however, it is preferably 10 μm or more, and more preferably 25 μm or more from a viewpoint of the handleability when peeling the separator. From a viewpoint of ease of peeling of the separator, the thickness is preferably 200 μm or less, and more preferably 100 μm or less.

[0023]

When the separator 16 is viewed in plan, the size and the shape thereof are not particularly limited. As described in the present embodiment, the size and the shape may be equivalent to those of the sealing sheet 11 when this sheet is viewed in plan (see Fig. 1). When the separator 16 is viewed in plan, the size and the shape thereof may be larger than those of the sealing sheet 11.

[0024]

Embossing may be applied to the surface of the separator 16 that contacts the sealing sheet 11. The embossing can further improve the external appearance after the step D.

[0025]

(Sealing Sheet)

The constituent material of the sealing sheet 11 preferably includes a thermosetting resin. The constituent material in particular preferably includes an epoxy resin, and a phenolic resin as a curing agent. In this case, a good thermosetting property of the sealing sheet can be achieved. Moreover, when the sealing sheet 11 contains the epoxy resin, the peel strength between the sealing sheet and the separator 16 can be made lower after the heating of these two members.

[0026]

The epoxy resin is not especially limited. For example, various kinds of epoxy resins can be used such as a

triphenylmethane-type epoxy resin, a cresol novolac-type epoxy resin, a biphenyl-type epoxy resin, a modified bisphenol A-type epoxy resin, a bisphenol A-type epoxy resin, a bisphenol F-type epoxy resin, a modified bisphenol F-type epoxy resin, a dicyclopentadiene-type epoxy resin, a phenol novolac-type epoxy resin, and a phenoxy resin. These epoxy resins may be used alone or in combination of two or more thereof.

[0027]

From the viewpoint of securing the toughness of the epoxy resin after curing and the reactivity of the epoxy resin, epoxy resins are preferable which are solid at normal temperature and have an epoxy equivalent of 150 to 200 and a softening point or melting point of 50 to 130°C. Among these epoxy resins, a triphenylmethane-type epoxy resin, a cresol novolac-type epoxy resin, and a biphenyl-type epoxy resin are more preferable from the viewpoint of reliability.

[0028]

The phenol resin is not especially limited as long as it initiates curing reaction with the epoxy resin. For example, there can be used a phenol novolac resin, a phenolaralkyl resin, a biphenylaralkyl resin, a dicyclopentadiene-type phenol resin, a cresol novolac resin, a resol resin, etc. These phenol resins may be used alone or in combination of two or more thereof.

[0029]

From the viewpoint of the reactivity with the epoxy resin,

phenol resins are preferably used which have a hydroxy group equivalent of 70 to 250 and a softening point of 50 to 110°C. Among these phenol resins, a phenol novolac resin is more preferably used from the viewpoint of its high curing reactivity. Further, phenol resins having low moisture absorbability can be also preferably used such as a phenolaralkyl resin and a bisphenylaralkyl resin from the viewpoint of reliability.

[0030]

For the compounding ratio of the phenol resin to the epoxy resin, the epoxy resin and the phenol resin are preferably compounded so that the total amount of the hydroxy group in the phenol resin is 0.7 to 1.5 equivalents, and more preferably 0.9 to 1.2 equivalents, to 1 equivalent of the epoxy group in the epoxy resin.

[0031]

The total content of the epoxy resin and the phenol resin in the sealing sheet 11 is preferably 2.5% by weight or more, and more preferably 3.0% by weight or more. If the content is 2.5% by weight or more, good adhering strength to the semiconductor chips 23 and the semiconductor wafer 22 can be obtained. The total content of the epoxy resin and the phenol resin in the sealing sheet 11 is preferably 20% by weight or less, and more preferably 10% by weight or less. If the content is 20% by weight or less, moisture absorbability can be decreased.

[0032]

The sealing sheet 11 may contain a thermoplastic resin. This makes it possible to provide a handling property when the sealing sheet 11 is uncured and low stress property to the cured product.

[0033]

Examples of the thermoplastic resin include natural rubber, butyl rubber, isoprene rubber, chloroprene rubber, an ethylene-vinylacetate copolymer, an ethylene-acrylic acid copolymer, an ethylene-acrylate copolymer, a polybutadiene resin, a polycarbonate resin, a thermoplastic polyimide resin, polyamide resins such as 6-nylon and 6,6-nylon, a phenoxy resin, an acrylic resin, saturated polyester resins such as PET and PBT, a polyamideimide resin, a fluororesin, and a styrene-isobutylene-styrene block copolymer. These thermoplastic resins may be used alone or in combination of two or more thereof. Among these, a styrene-isobutylene-styrene block copolymer is preferable from the viewpoint of its low stress property and low moisture absorption.

[0034]

The content of the thermoplastic resin in the sealing sheet 11 may be 1.5% by weight or more, or 2.0% by weight or more. If the content is 1.5% by weight or more, the flexibility can be obtained. The content of the thermoplastic resin in the sealing sheet 11 is preferably 6% by weight or less, and more

preferably 4% by weight or less. If the content is 4% by weight or less, the adhesion with the semiconductor chips 23 and the semiconductor wafer 22 is good.

[0035]

The sealing sheet 11 preferably contains an inorganic filler.

[0036]

The inorganic filler is not especially limited, and various kinds of conventionally known fillers can be used. Examples thereof include powders of quartz glass, talc, silica (such as fused silica and crystalline silica), alumina, aluminum nitride, silicon nitride, and boron nitride. These may be used alone or in combination of two or more kinds. Among these, silica and alumina are preferable, and silica is more preferable due to the reason that the linear expansion coefficient can be satisfactorily decreased.

[0037]

As silica, silica powders are preferable, and fused silica powders are more preferable. Examples of the fused silica powders include spherical fused silica powders and crushed and fused silica powders. However, spherical fused silica powders are preferable from the viewpoint of fluidity. Among these, powders having an average particle size of 10 to 30 μm are preferable, and powders having an average particle size of 15 to 25 μm are more preferable.

The average particle size can be obtained, for example, by measurement on a sample that is extracted arbitrarily from the population using a laser diffraction-scattering type particle size distribution measuring apparatus. Among these, silica powders are preferable having an average particle size of 10 μm to 30 μm , and more preferable having an average particle size of 15 μm to 25 μm .

For example, the average particle size can be measured by using a laser diffraction-scattering type particle size distribution measuring apparatus on a sample that is arbitrarily extracted from the population.

[0038]

The content of the inorganic filler in the sealing sheet 11 is preferably 75% by weight to 95% by weight, and more preferably 78% by weight to 95% by weight relative to the total content of the sealing sheet 11. If the content of the inorganic filler is 75% by weight or more relative to the total content of the sealing sheet 11, the thermal expansion coefficient can be kept low, and thus mechanical damage due to thermal impact can be suppressed. On the other hand, if the content of the inorganic filler is 95% by weight or less relative to the total content of the sealing sheet 11, the flexibility, the fluidity, and the adhesion become more satisfactory.

[0039]

The sealing sheet 11 preferably contains a curing

accelerator.

[0040]

The curing accelerator is not especially limited as long as it promotes curing of the epoxy resin and the phenol resin, and examples of the curing accelerator include organophosphate compounds such as triphenylphosphine and tetraphenylphosphonium tetraphenylborate; and imidazole compounds such as 2-phenyl-4,5-dihydroxymethylimidazole and 2-phenyl-4-methyl-5-hydroxymethylimidazole. Among these, 2-phenyl-4,5-dihydroxymethylimidazole is preferable due to the reason that the curing reaction does not rapidly proceed even when the temperature increases during kneading and the sealing sheet 11 can be produced satisfactorily.

[0041]

The content of the curing accelerator is preferably 0.1 to 5 parts by weight to the total 100 parts by weight of the epoxy resin and the phenol resin.

[0042]

The sealing sheet 11 may contain a flame retardant component. This makes it possible to reduce an expansion of combustion when the sealing sheet 11 catches fire due to short circuit of the parts or heat generation. Examples of the flame retardant component include various kinds of metal hydroxides such as aluminum hydroxide, magnesium hydroxide, iron hydroxide, calcium hydroxide, tin hydroxide, and composite metal

hydroxide; and a phosphazene flame retardant.

[0043]

The sealing sheet 11 preferably contains a silane coupling agent. The silane coupling agent is not especially limited, and an example includes 3-glycidoxypopyl trimethoxysilane.

[0044]

The content of the silane coupling agent in the sealing sheet 11 is preferably 0.1 to 3% by weight. If the content is 0.1% by weight or more, the strength of the cured product is sufficiently made high, so that the water absorption can be lowered. If the content is 3% by weight or less, the amount of outgas can be decreased.

[0045]

The sealing sheet 11 preferably contains a pigment or dye. The pigment is not particularly limited, and may be, for example, carbon black.

[0046]

The content of the pigment or dye in the sealing sheet 11 is preferably from 0.1 to 2% by weight. When the content is 0.1% by weight or more, a good marking property of the sealing sheet can be obtained. When the content is 2% by weight or less, the sealing sheet can ensure strength after being cured.

[0047]

Besides the above-mentioned individual components, any

other additive may be appropriately blended into the sealing sheet 11, as required.

[0048]

The thickness of the sealing sheet 11 is not particularly limited, and it is 50 μm to 2,000 μm for example, preferably 70 μm to 1,200 μm , and more preferably 100 μm to 700 μm from the viewpoint of using it as a sealing sheet and in which the semiconductor chip 23 can be suitably embedded.

[0049]

The size and the shape of the sealing sheet 11 are not particularly limited. When viewed in plan, the sealing sheet 11 preferably has such a shape that the sheet can be laminated on a semiconductor wafer 22 (a stacked body) without protruding from the wafer. When viewed in plan, the size and the shape of the sealing sheet 11 may be, for example, equivalent to or larger than those of the semiconductor wafer 22 (the stacked body) when viewed in plan.

[0050]

In the separator-equipped sealing sheet 10, the peel strength Z1 between the sealing sheet 11 and the separator 16 each heated at 150°C for 1 hour is preferably less than 0.4 N/100 mm width, more preferably less than 0.35 N/100 mm width, even more preferably less than 0.3 N/100 mm width under conditions of a peeling angle of 180° and a peel rate of 300 mm/minute. When the peel strength Z1 is less than 0.4 N/100 mm, the separator

16 can more easily be peeled off from the sealing sheet 11 after the sealing sheet 11 is thermally cured. As the peel strength Z1 is smaller, more preferred results are obtained. However, this strength is, for example, 0.01 N/100 mm width or more.

[0051]

The method of manufacturing the sealing sheet 11 is not especially limited; however, preferred examples are a method of preparing a kneaded product of the resin composition for forming the sealing sheet 11 and applying the obtained kneaded product and a method of subjecting the obtained kneaded product to plastic-working to be formed into a sheet shape. This makes it possible to produce the sealing sheet 11 without using a solvent. Therefore, the effects on the semiconductor chip 23 from the volatilized solvent can be suppressed.

[0052]

Specifically, each component described later is melted and kneaded with a known kneader such as a mixing roll, a pressure kneader, or an extruder to prepare a kneaded product, and the obtained kneaded product is applied or plastic-worked into a sheet shape. As a kneading condition, the temperature is preferably the softening point or higher of each component described above, and is for example 30 to 150°C. When the thermal curing property of the epoxy resin is considered, the temperature is preferably 40 to 140°C, and more preferably 60 to 120°C. The time is for example 1 to 30 minutes, and preferably

5 to 15 minutes.

[0053]

The kneading is preferably performed under a reduced pressure condition (under reduced pressure atmosphere). This makes it possible to remove gas, and to prevent invasion of gas into the kneaded product. The pressure under the reduced pressure condition is preferably 0.1 kg/cm^2 or less, and more preferably 0.05 kg/cm^2 or less. The lower limit of the pressure under reduced pressure is not especially limited; however, it is $1 \times 10^{-4} \text{ kg/cm}^2$ or more.

[0054]

When the kneaded product is applied to form the sealing sheet 11, the kneaded product after being melt-kneaded is preferably applied while it is at high temperature without being cooled. The application method is not especially limited, and examples thereof include bar coating, knife coating, and slot-die coating. The application temperature is preferably the softening point or higher of each component described above. When the thermal curing property and molding property of the epoxy resin are considered, the temperature is for example 40 to 150°C , preferably 50 to 140°C , and more preferably 70 to 120°C .

[0055]

When forming the sealing sheet 11 by plastic-working the kneaded product, the kneaded product after melt-kneaded is preferably subjected to plastic-working while it is at high

temperature without being cooled. The plastic-working process is not especially limited, and examples thereof include flat plate pressing, T-die extrusion, screw-die extrusion, rolling, roll kneading, inflation extrusion, coextrusion, and calendar molding. The temperature for plastic-working is preferably the softening point or higher of each component described above. When the thermal curing property and molding property of the epoxy resin are considered, the temperature is for example 40 to 150°C, preferably 50 to 140°C, and more preferably 70 to 120°C.

[0056]

The resin, etc. for forming the sealing sheet 11 can be dissolved and dispersed into an appropriate solvent to prepare varnish, and the varnish can be applied to obtain the sealing sheet 11.

[0057]

The above has described the separator-equipped sealing sheet 10.

[0058]

The following will describe a semiconductor device production method using the separator-equipped sealing sheet 10.

[0059]

A semiconductor device production method according to the present embodiment includes the following steps:

a step A of providing a stacked body including a

semiconductor wafer and a semiconductor chip flip-chip bonded onto a circuit-forming surface of the semiconductor wafer;

a step B of disposing a sealing sheet and a protective film on the semiconductor chip of the stacked body;

a step C of burying the semiconductor chip in the sealing sheet to form a sealed body including the semiconductor chip buried in the sealing sheet;

a step D of thermally curing the sealing sheet of the sealed body; and

a step E of peeling off the protective film after the step D.

The case will be explained in the present embodiment in which "the laminate in which the semiconductor chips are fixed on a support" of the present invention is "a laminate in which the semiconductor chips are flip-chip bonded to the circuit formation surface of the semiconductor wafer". The present embodiment is what is called a method for manufacturing a semiconductor device using a chip-on-wafer process.

[0060]

Figs. 2 to 11 are schematic cross sections for explaining a method for manufacturing a semiconductor device according to the present embodiment.

[0061]

[Preparation step]

In the method for manufacturing a semiconductor device

according to the present embodiment, a laminate 20 is first prepared in which a semiconductor chip 23 is flip-chip bonded to a circuit formation surface 22a of a semiconductor wafer 22 (Step A). In the first embodiment, the semiconductor wafer 22 corresponds to "the support" of the present invention. For example, the laminate 20 can be obtained as below.

[0062]

As shown in Fig. 2, one or a plurality of the semiconductor chips 23 each having a circuit formation surface 23a and the semiconductor wafer 22 having the circuit formation surface 22a are prepared. The case will be explained below in which a plurality of semiconductor chips is flip-chip bonded to a semiconductor wafer. The shape and the size of the semiconductor wafer 22 (support) in planar view can be same as the size and the shape of the sealing sheet 11 in planar view. For example, the size and the shape can be a circular shape having a diameter of 200 mm or more.

[0063]

Next, as illustrated in Fig. 3, the semiconductor chips 23 are flip-chip bonded to the circuit-forming surface 22a of the semiconductor wafer 22. For the mounting of the semiconductor chips 23 onto the semiconductor wafer 22, a known apparatus is usable, which is, for example, a flip-chip bonder or a die bonder. Specifically, bumps 23b formed in the circuit-forming surface 23a of each of the semiconductor chips

23 are electrically connected to electrodes 22b formed in the circuit-forming surface 22a of the semiconductor wafer 22. This manner makes it possible to yield a laminate 20 in which the semiconductor chips 23 are mounted on the semiconductor wafer 22. At this time, a resin sheet 24 for underfill may be bonded to the circuit-forming surface 23a of each of the semiconductor chips 23. In this case, by flip-chip bonding the semiconductor chips 23 onto c, gaps between the semiconductor chips 23 and the semiconductor wafer 22 can be sealed up with the resin. A method for flip-chip bonding the semiconductor chips 23, to which the resin sheets 24 for underfill are bonded, onto the semiconductor wafer 22 is disclosed in, for example, JP-A-2013-115186; thus, detailed description thereabout is omitted herein.

[0064]

[Step of Providing Separator-Equipped Sealing Sheet]

In the semiconductor device production method according to the present embodiment, a separator-equipped sealing sheet 10 (see Fig. 1) is also provided, the separator-equipped sealing sheet 10 including a separator 16 and a sealing sheet 11 beforehand laminated on the separator 16 (step X).

[0065]

[Step of Disposing Separator-Equipped Sealing Sheet on Stacked Body]

After the steps A and X, as illustrated in Fig. 4, the

stacked body 20 is disposed on a lower heating plate 32 to direct the semiconductor-chip-23-mounted surface of the stacked body 20 upward, and further the separator-equipped sealing sheet 11 is disposed on the semiconductor chips 23 of the stacked body 20 to bring the semiconductor chips 23 into contact with the sealing sheet 11 (step B). In this step, it is allowable to dispose the stacked body 20 initially on the lower heating plate 32, and subsequently dispose the separator-equipped sealing sheet 11 on the stacked body 20; or stack the separator-equipped sealing sheet 11 first on the stacked body 20, and subsequently dispose the resultant stacked product, which includes the stacked body 20 and the separator-equipped sealing sheet 11 stacked on each other, on the lower heating plate 32.

[0066]

[Step of forming sealed body]

Next, the semiconductor chip 23 is embedded in the sealing sheet 11 by heat pressing with the lower heating plate 32 and upper heating plate 34 as shown in Fig. 5 to form a sealed body 28 in which the semiconductor chip 23 is embedded in the sealing sheet 11 (Step C).

[0067]

For the hot pressing condition when the semiconductor chip 23 is embedded into the sealing sheet 11, the temperature is for example 40 to 100°C, and preferably 50 to 90°C; the pressure is for example 0.1 to 10 MPa, and preferably 0.5 to

0.8 MPa; and the duration is for example 0.3 to 10 minutes, and preferably 0.5 to 5 minutes. This makes it possible to provide a semiconductor device in which the semiconductor chip 23 is embedded in the sealing sheet 11. In consideration of improvement of the tackiness and followability of the sealing sheet 11 to the semiconductor chip 23 and the semiconductor wafer 22, pressing is preferably performed under a reduced pressure condition.

For the reduced pressure condition, the pressure is for example 0.1 to 5 kPa, and preferably 0.1 to 100 Pa; and the reduced pressure maintaining time (time from start of reducing pressure to start of pressing) is for example 5 to 600 seconds, and preferably 10 to 300 seconds.

[0068]

[Trimming Step]

After the step C, as illustrated in Fig. 6, the resin (sealing sheet 11) pushed to flow in the plane direction of the sealing sheet in the step C is cut as required to remove the protruding portion of the resin.

[0069]

[Thermal curing step]

Next, the sealing sheet 11 is thermally cured (step D). Specifically, for example, the entire sealed body 28 is heated in which the semiconductor chip 23 mounted on the semiconductor wafer 22 is embedded in the sealing sheet 11.

[0070]

The heating temperature of the thermal curing treatment is preferably 100°C or more, and more preferably 120°C or more. On the other hand, the upper limit of the heating temperature is preferably 200°C or less and more preferably 180°C or less. The heating time is preferably 10 minutes or more, and more preferably 30 minutes or more. On the other hand, the upper limit of the heating time is preferably 180 minutes or less, and more preferably 120 minutes or less. A pressure is preferably applied in the thermal curing treatment. The pressure is preferably 0.1 MPa or more, and more preferably 0.5 MPa or more. On the other hand, the upper limit thereof is preferably 10 MPa or less, and more preferably 5 MPa or less.

[0071]

[Release Liner Peeling Step]

Next, as illustrated in Fig. 7, the separator 16 is peeled off from the sealed body (step E). The surface of the separator 16 that contacts the sealing sheet 11 is a surface treated with the aminoalkyd release agent; thus, the separator can easily be peeled off from the sealing sheet 11 after the thermal curing of the sealing sheet.

[0072]

[Step of Grinding Sealing sheet]

Next, as illustrated in Fig. 8, the sealing sheet 11 of the sealed body 28 is ground to expose respective rear surfaces

23c of the semiconductor chips 23. The method for grinding the sealing sheet 11 is not particularly limited, and may be, for example, a grinding method using a grinding stone rotatable at a high velocity.

[0073]

[Step of Forming Interconnect Layer]

Next, the semiconductor wafer surface opposite to the semiconductor-chip-23-mounted surface of the semiconductor wafer 22 is ground to make vias 22c (see Fig. 9), and then an interconnect layer 27 is formed which has interconnects 27a (see Fig. 10). The method for grinding the semiconductor wafer 22 is not particularly limited, and is, for example, a grinding method using a grinding stone rotatable at a high velocity. Bumps 27b projected from the interconnects 27a may be formed in the interconnect layer 27. It is allowable to apply, to the method of forming the interconnect layer 27, a technique known in the prior art for manufacturing a circuit board or interposer, such as a semi-additive method or a subtractive method. Thus, detailed description thereabout is omitted herein.

[0074]

[Dicing Step]

Subsequently, as illustrated in Fig. 11, the sealed body 28 from which the rear surfaces 23c of the semiconductor chips 23 are exposed are diced. Through this step, semiconductor devices 29, which correspond to the respective units of the

semiconductor chips 23, can be obtained.

[0075]

[Substrate Mounting Step]

As required, a substrate mounting step may be performed in which each of the semiconductor devices 29 is mounted onto a different substrate (not illustrated). For the mounting of the semiconductor device 29 onto the different substrate, a known apparatus such as a flip-chip bonder or die bonder is usable.

[0076]

Through the above-mentioned semiconductor device production method according to the present embodiment, the separator-equipped sealing sheet 10 is disposed on the semiconductor chips 23, and subsequently the semiconductor chips 23 are buried in the sealing sheet 11 to form the sealed body 28 including the semiconductor chips 23 buried in the sealing sheet 11 (step C). The sealing sheet 11 of the sealed body 28 is thermally cured in the state of being equipped with the separator 16 (step D). Since the sealing sheet 11 is thermally cured in the state of being equipped with the separator 16, the surface of the sealing sheet 11 can be restrained from being roughened at the time of the thermal curing of this sheet. After the thermal curing, the separator 16 is peeled off from the sealing sheet 11 (step E). The surface of the separator 16 that contacts the sealing sheet 11 is treated

with the aminoalkyd release agent; thus, the separator 16 can easily be peeled off from the sealing sheet 11 after the thermal curing of the sealing sheet. Even after the thermal curing, the separator 16 can easily be peeled off from the sealing sheet 11 so that the surface of the sealing sheet is restrained from being roughened. Thus, the semiconductor devices 29 having a good external appearance can be obtained.

[0077]

The description about the above-mentioned embodiment has been made about a case where the semiconductor chips 23 are buried in the sealing sheet 11 through hot-pressing using the lower heating plate 32 and the upper heating plate 34 to form the sealed body 28 including the semiconductor chips 23 buried in the sealing sheet 11. In short, the description has been made about a case where the semiconductor chips are buried in the sealing sheet by flat plate pressing. In the present invention, however, the step C of forming the sealed body including the semiconductor chips buried in the sealing sheet is not limited to this example. For example, the step C may make use of compression molding using a mold.

[0078]

The description about the above-mentioned embodiment has been made about a case where the sealing sheet of the separator-equipped sealing sheet has a monolayer structure. However, the layer structure of the sealing sheet in the present

invention is not limited to this example. Thus, the sealing sheet may have two or more layers.

[0079]

The description about the above-mentioned embodiment has been made about a case where the semiconductor device production method according to the present invention is a method for producing the so-called chip-on-wafer semiconductor devices. In other words, the description has been made about a case where a "stacked body including a support and a semiconductor chip fixed onto the support" is a "stacked body including a semiconductor wafer and a semiconductor chip flip-chip bonded onto a circuit-forming surface of the semiconductor wafer".

However, the semiconductor device production method according to the present invention is not limited to this example. The support in the present invention may be a temporary fixing member, which is removed after the step D (the step of thermally curing the sealing sheet of the sealed body).

Specifically, the semiconductor device production method according to another embodiment is a semiconductor device production method including the following steps:

a step A of providing a stacked body including a temporary fixing member and a semiconductor chip temporarily fixed onto the temporary fixing member;

a step B of disposing a sealing sheet and a protective film on the semiconductor chip of the stacked body;

a step C of burying the semiconductor chip in the sealing sheet to form a sealed body including the semiconductor chip buried in the sealing sheet;

a step D of thermally curing the sealing sheet of the sealed body; and

a step E of peeling off the protective film after the step D.

In this case, a re-interconnection may be formed at a spot where the semiconductor chip is exposed (circuit-forming surface) of the wafer. This manner makes it possible to produce a semiconductor device called a fan-out wafer level package (WLP). The temporary fixing member may be, for example, a thermally peelable sheet containing a conventionally known foaming agent. The thermally peelable sheet is described in detail as a thermally expandable pressure-sensitive adhesive layer in JP-A-2009-040930 and others. Thus, any description thereabout is omitted herein.

[0080]

The present invention is not limited to the above-mentioned embodiments. Each of the steps may or may not be performed as far as a method resulting from the modification does not depart from the subject matter of the invention. Moreover, these steps may be performed in any order as far as such order does not depart from the subject matter of the invention.

EXAMPLES

[0081]

Hereinafter, the present invention will be described in detail by way of examples thereof. However, the invention is not limited to the examples as far as any other example does not depart from the subject matters of the present invention. In each of the examples, the word "part(s)" denotes part(s) by weight unless otherwise specified.

[0082]

<Production of Sealing Sheet>

(Example 1)

The following were blended together: 100 parts of an epoxy resin A (trade name: "YSLV-80XY", manufactured by Nippon Steel Chemical Co., Ltd.); 97 parts of an epoxy resin B (trade name: "EPIKOTE 828", bisphenol A type epoxy resin, manufactured by Mitsubishi Chemical Corporation; epoxy equivalent: 185 g/eq); 90 parts of a phenolic resin (trade name: "MEH-7500-3S", manufactured by Meiwa Plastic Industries, Ltd.); 2894 parts of an inorganic filler A (trade name: "FB-9454FC", manufactured by DENKI KAGAKU KOGYO KABUSHIKI KAISHA); 99 parts of an inorganic filler B (trade name: "FB-5SDC", spherical fused silica, manufactured by DENKI KAGAKU KOGYO KABUSHIKI KAISHA; average particle diameter: 5 μ m); 3 parts of a silane coupling agent (trade name: "KBM-403", manufactured by Shin-Etsu

Chemical Co., Ltd.); 7 parts of carbon black (trade name: "#20", manufactured by Mitsubishi Chemical Corporation); and 3 parts of a curing accelerator (trade name: "2PHZ-PW", manufactured by SHIKOKU CHEMICALS CORPORATION). A roll kneader was used to heat the blend at 60°C for 2 minutes, at 80°C for 2 minutes and at 120°C for 6 minutes in this order. In this way, the blend was melted and kneaded under a reduced-pressure condition (0.01 kg/cm²) over the total period of 10 minutes to prepare a kneaded product. Next, the resultant kneaded product was applied onto a separator by a slot die method at 120°C to be made into a sheet form. Thus, a sealing sheet A of 500 μm thickness was produced. The used separator was a polyethylene terephthalate film (trade name: "PET-50-SHP-AO", manufactured by FUJI CORPORATION) of 50 μm thickness which had a surface subjected to release treatment with an aminoalkyd release agent. Subsequently, the same separator was bonded onto the exposed surface of the sealing sheet A to produce a double-sided separator-equipped sealing sheet A.

[0083]

(Example 2)

The following were blended together: 100 parts of an epoxy resin A (trade name: "YSLV-80XY", manufactured by Nippon Steel Chemical Co., Ltd.); 85 parts of a phenolic resin (trade name: "MEH-7851-3S", manufactured by Meiwa Plastic Industries, Ltd.); 84 parts of a thermoplastic resin (trade name: "SIBSTAR

072T", manufactured by KANEKA CORPORATION); 2254 parts of an inorganic filler A (trade name: "FB-9454FC", manufactured by DENKI KAGAKU KOGYO KABUSHIKI KAISHA); 2 parts of a silane coupling agent (trade name: "KBM-403", manufactured by Shin-Etsu Chemical Co., Ltd.); 8 parts of carbon black (trade name: "#20", manufactured by Mitsubishi Chemical Corporation); and 3 parts of a curing accelerator (trade name: "2PHZ-PW", manufactured by SHIKOKU CHEMICALS CORPORATION). A roll kneader was used to heat the blend at 60°C for 2 minutes, at 80°C for 2 minutes and at 120°C for 6 minutes in this order. In this way, the blend was melted and kneaded under a reduced-pressure condition (0.01 kg/cm²) over the total period of 10 minutes to prepare a kneaded product. Next, the resultant kneaded product was applied onto a separator by a slot die method at 120°C to be made into a sheet form. Thus, a sealing sheet B of 500 μm thickness was produced. The used separator was a polyethylene terephthalate film (trade name: "PET-50-SHP-AO", manufactured by FUJI CORPORATION) of 50 μm thickness which had a surface subjected to release treatment with an aminoalkyd release agent. Subsequently, the same separator was bonded onto the exposed surface of the sealing sheet B to produce a double-sided separator-equipped sealing sheet B.

[0084]

(Example 3)

The following were blended together: 100 parts of an epoxy

resin A (trade name: "YSLV-80XY", manufactured by Nippon Steel Chemical Co., Ltd.); 169 parts of an epoxy resin B (trade name: "EPIKOTE 828", bisphenol A type epoxy resin, manufactured by Mitsubishi Chemical Corporation; epoxy equivalent: 185 g/eq); 169 parts of a phenolic resin (trade name: "MEH-7851-SS", manufactured by Meiwa Plastic Industries, Ltd.); 96 parts of a thermoplastic resin (trade name: "SIBSTAR 072T", manufactured by KANEKA CORPORATION); 4685 parts of an inorganic filler A (trade name: "FB-9454FC", manufactured by DENKI KAGAKU KOGYO KABUSHIKI KAISHA); 145 parts of an inorganic filler B (trade name: "FB-5SDC", spherical fused silica, manufactured by DENKI KAGAKU KOGYO KABUSHIKI KAISHA; average particle diameter: 5 μm); 9 parts of a silane coupling agent (trade name: "KBM-403", manufactured by Shin-Etsu Chemical Co., Ltd.); 11 parts of carbon black (trade name: "#20", manufactured by Mitsubishi Chemical Corporation); and 5 parts of a curing accelerator (trade name: "2PHZ-PW", manufactured by SHIKOKU CHEMICALS CORPORATION). A roll kneader was used to heat the blend at 60°C for 2 minutes, at 80°C for 2 minutes and at 120°C for 6 minutes in this order. In this way, the blend was melted and kneaded under a reduced-pressure condition (0.01 kg/cm²) over the total period of 10 minutes to prepare a kneaded product. Next, the resultant kneaded product was applied onto a separator by a slot die method at 120°C to be made into a sheet form. Thus, a sealing sheet C of 500 μm thickness was produced. The used separator

was a polyethylene terephthalate film (trade name: "PET-50-SHP-AO", manufactured by FUJI CORPORATION) of 50 μm thickness which had a surface subjected to release treatment with an aminoalkyd release agent. Subsequently, the same separator was bonded onto the exposed surface of the sealing sheet C to produce a double-sided separator-equipped sealing sheet C.

[0085]

(Example 4)

The following were blended together: 100 parts of an epoxy resin A (trade name: "YSLV-80XY", manufactured by Nippon Steel Chemical Co., Ltd.); 55 parts of a phenolic resin (trade name: "H-4", manufactured by Meiwa Plastic Industries, Ltd.); 473 parts of an inorganic filler A (trade name: "FB-5SDC", manufactured by DENKI KAGAKU KOGYO KABUSHIKI KAISHA); 0.2 part of a silane coupling agent (trade name: "KBM-403", manufactured by Shin-Etsu Chemical Co., Ltd.); 1 part of carbon black (trade name: "#20", manufactured by Mitsubishi Chemical Corporation); and 2 parts of a curing accelerator (trade name: "2E4MZ-A", manufactured by SHIKOKU CHEMICALS CORPORATION). A roll kneader was used to heat the blend at 60°C for 2 minutes, at 80°C for 2 minutes and at 120°C for 6 minutes in this order. In this way, the blend was melted and kneaded under a reduced-pressure condition (0.01 kg/cm²) over the total period of 10 minutes to prepare a kneaded product. Next, the resultant

kneaded product was applied onto a separator by a slot die method at 120°C to be made into a sheet form. Thus, a sealing sheet D of 500 μm thickness was produced. The used separator was a polyethylene terephthalate film (trade name: "PET-50-SHP-AO", manufactured by FUJI CORPORATION) of 50 μm thickness which had a surface subjected to release treatment with an aminoalkyd release agent. Subsequently, the same separator was bonded onto the exposed surface of the sealing sheet D to produce a double-sided separator-equipped sealing sheet D.

[0086]

(Comparative Example 1)

A double-sided separator-equipped sealing sheet E was yielded in the same way as in Example 1 except that the used separator was a polyethylene terephthalate film of 50 μm thickness which was subjected to silicone release treatment.

[0087]

(Comparative Example 2)

A double-sided separator-equipped sealing sheet F was yielded in the same way as in Example 2 except that the used separator was a polyethylene terephthalate film of 50 μm thickness which was subjected to silicone release treatment.

[0088]

(Comparative Example 3)

A double-sided separator-equipped sealing sheet G was yielded in the same way as in Example 3 except that the used

separator was a polyethylene terephthalate film of 50 μm thickness which was subjected to silicone release treatment.

[0089]

(Comparative Example 4)

A double-sided separator-equipped sealing sheet H was yielded in the same way as in Example 4 except that the used separator was a polyethylene terephthalate film of 50 μm thickness which was subjected to silicone release treatment.

[0090]

(Production of Each Sample for Peel Strength Measurement)

The separator on one side of each of the produced double-sided separator-equipped sealing sheets A to H was peeled off, and then the sealing sheet was disposed on a silicon wafer having a width of 100 mm, a length of 200 mm, and a thickness of 780 μm . At this time, the sealing sheet and the wafer were arranged to bring a surface of the silicon wafer into contact with a surface of the sealing sheet. Next, a vacuum press machine (trade name: "VACUUM ACE", manufactured by Mikado Technos Co., Ltd.) was used to hot-press the sheet-attached wafer under conditions described below to yield a stacked product of the silicon wafer and the sealing sheet (silicon wafer thickness: 780 μm ; sealing sheet thickness: 300 μm ; and total thickness: 1080 μm). Thereafter, the stacked product was heated in a hot air dryer of 150°C for 1 hour to yield a sample for peel strength measurement.

<Hot-Pressing Conditions>

Vacuum pressure: 10 Pa

Pressing pressure: 1.0 MPa

Pressing temperature: a temperature at which the sealing sheet came to have a minimum melt viscosity

Pressing period: 60 seconds

<Method for Measuring Temperature at Which Sealing Sheet Came to Have Minimum Melt Viscosity>

A dynamic viscoelasticity measuring instrument (ARES, manufactured by TA Instruments) was used to measure the minimum melt viscosity of each of the sealing sheets (measuring conditions: plate diameter: 25 mm; gap: 1 mm; temperature rise rate: 10°C/min.; frequency: 1 Hz; strain quantity: 10%; and temperature range: 50 to 150°C; the measurement was made while the temperature was raised at 10°C/min.). The lowest value obtained in the measurement was defined as the minimum melt viscosity of the sealing sheet.

[0091]

(Peel Strength Z1 between Sealing Sheet and Separator Each Heated at 150°C for 1 Hour)

From the sealing sheet of each of the samples for peel strength measurement, the separator was peeled off, and the peel strength Z1 therebetween was measured. Specifically, the peeling was performed under conditions described below. Among loads obtained at this time, the maximum load (maximum load

value except the peak top value of the initial stage of the measurement) was measured. This maximum load was obtained as the peel strength (N/100 mm width) between the sealing sheet and the separator. The thermal curing at 150°C for 1 hour simulates the step D of thermally curing the sealing sheet. In other words, the sample for peel strength measurement after the thermal curing at 150°C for 1 hour simulates the sample in a state after the step D. The results are shown in Tables 1 and 2. In Comparative Examples 1 to 4, their separator failed in being peeled off from their sealing sheet. Thus, the tables do not show any value.

(Peel Strength Measuring Conditions)

Used machine: Autograph AGS-K (manufactured by Shimadzu Corporation)

Temperature: 23°C

Peeling angle: 180°

Tension rate: 300 mm/min

[0092]

(Evaluation of Peeling Property)

In the measurement of the peel strength Z1 of the sample, the sample was evaluated to be good (○) when the peeling of the separator succeeded. Alternatively, when the peeling failed, the sample was evaluated to be bad (×). The results are shown in Tables 1 and 2.

[0093]

[Table 1]

	Example 1	Example 2	Example 3	Example 4
Peel strength Z1 [N/100 mm width] after thermal curing	0.2	0.1	0.15	0.3
Evaluation of peeling property	○	○	○	○

[0094]

[Table 2]

	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4
Peel strength Z1 [N/100 mm width] after thermal curing	-	-	-	-
Evaluation of peeling property	x	x	x	x

DESCRIPTION OF REFERENCE SIGNS

[0095]

10: Separator-equipped sealing sheet

11: Sealing sheet

16: Separator

20: Stacked body

22: Semiconductor wafer (support)

23: Semiconductor chip

28: Sealed body

29: Semiconductor device

CLAIMS

1. A separator-equipped sealing sheet, comprising:
a separator, and
a sealing sheet laminated on the separator;
wherein a surface of the separator that contacts the
sealing sheet is treated with an aminoalkyd release agent.

2. The separator-equipped sealing sheet according to
claim 1, having a peel strength less than 0.4 N/100 mm width,
the peel strength being a peel strength between the sealing
sheet and the separator each heated at 150°C for 1 hour.

3. The separator-equipped sealing sheet according to
claim 1 or 2, wherein the sealing sheet contains an epoxy resin.

4. A semiconductor device production method,
comprising:

a step A of providing a stacked body including a support
and a semiconductor chip fixed onto the support;

a step X of providing the separator-equipped sealing
sheet recited in any one of claims 1 to 3;

a step B of disposing the separator-equipped sealing
sheet on the semiconductor chip of the stacked body;

a step C of burying the semiconductor chip in the sealing

sheet to form a sealed body including the semiconductor chip buried in the sealing sheet;

a step D of thermally curing the sealing sheet of the sealed body; and

a step E of peeling off the separator after the step D.