DESCRIPTION

TITLE OF THE INVENTION: RESIN COMPOSITION, SEMICONDUCTOR DEVICE MANUFACTURING METHOD AND SEMICONDUCTOR DEVICE

TECHNICAL FIELD

[0001]

The present invention relates to a resin composition, a semiconductor device manufacturing method, and a semiconductor device.

BACKGROUND ART

[0002]

A technique of stacking semiconductor devices each having a semiconductor chip built-in (hereinafter, the devices will be referred to also as the semiconductor packages) onto each other (hereinafter, the technique will be referred to as the "package-on-package") has been put into practical use. With the progress of the practical use of the package-on-package, semiconductor devices are required to be made smaller in height.

[0003]

As a semiconductor device manufacturing technique, known is a technique of covering a semiconductor chip with a thermosetting resin sheet containing, for example, a thermosetting resin and a filler (see, for example, Patent Document 1).

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0004]

Patent Document 1: JP-A-2013-7028

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0005]

As illustrated in Fig. 30, semiconductor chips 514 can be covered with a thermosetting resin sheet 512 by pressing a structure 500 having the semiconductor chips 514 and the thermosetting resin sheet 512 which is located on the semiconductor chips 514. However, as the structure 500 is pressed, the filler is pushed onto the semiconductor chips 514, so that the semiconductor chips 514 may be damaged to be cracked. When the thermosetting resin sheet 512 is thin, the semiconductor chips 514 are easily cracked.

[0006]

An object of the present invention is to solve the problem, and provide a resin composition which can relieve damage imparted to a semiconductor chip. The present invention also provides a semiconductor device manufacturing method which can relieve damage imparted to a semiconductor chip.

MEANS FOR SOLVING THE PROBLEMS

[0007]

In order to solve the problem, the inventors have made eager investigations to find out that a value four times the average particle diameter of the filler is made equal to or less than the thickness of the resin composition, thereby making it possible to relieve damage imparted to a semiconductor chip. Thus, the present invention has been achieved.

[0008]

Accordingly, the present invention relates to a resin composition containing a filler, a value four times the average particle diameter of the filler being equal to or less than the thickness of the resin composition.

[0009]

In the present invention, the value four times the average particle diameter of the filler is equal to or less than the thickness of the resin composition; thus, damage imparted to a semiconductor chip can be relieved.

[0010]

The form of the resin composition is, for example, a tablet form or sheet form. Of these forms, a sheet form is preferred.

[0011]

The present invention also relates to a semiconductor device manufacturing method including the step of covering a

semiconductor chip with the resin composition.

EFFECT OF THE INVENTION

[0012]

The present invention makes it possible to relieve damage imparted to a semiconductor chip.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

Fig. 1 is a schematic sectional view of a thermosetting resin sheet.

Fig. 2 is a sectional view illustrating an outline of a situation of arranging a stacked body between a lower heating plate and an upper heating plate.

Fig. 3 is a sectional view illustrating an outline of a situation of hot-pressing the stacked body by a parallel plate method.

Fig. 4 is a schematic sectional view of a sealed body, and others.

Fig. 5 is a schematic sectional view of a cured body obtained by heating the sealed body, and others.

Fig. 6 is a schematic sectional view of the cured body.

Fig. 7 is a schematic sectional view of the cured body.

Fig. 8 is a sectional view illustrating an outline of a situation that a buffer coat film is formed on the cured body.

Fig. 9 is a sectional view illustrating an outline of a situation of radiating exposure light to the buffer coat film.

Fig. 10 is a sectional view illustrating an outline of a situation that openings are made in the buffer coat film.

Fig. 11 is a sectional view illustrating an outline of a situation that through holes are made in the film.

Fig. 12 is a sectional view illustrating an outline of a situation that through electrodes are formed in the holes.

Fig. 13 is a sectional view illustrating an outline of a situation that a resist is formed on a seed layer.

Fig. 14 is a sectional view illustrating an outline of a situation that a plating pattern is formed on the seed layer.

Fig. 15 is a sectional view illustrating an outline of a situation that re-interconnections are finished.

Fig. 16 is a sectional view illustrating an outline of a situation that a protective film is formed on the re-interconnections.

Fig. 17 is a schematic sectional view of a re-interconnection body.

Fig. 18 is a sectional view illustrating an outline of a situation that electrodes are formed on the re-interconnections.

Fig. 19 is a sectional view illustrating an outline of a situation that bumps are formed on the electrodes.

Fig. 20 is a schematic sectional view of semiconductor

devices.

Fig. 21 is a sectional view illustrating an outline of a state that a stacked structural body is arranged between a lower heating plate and an upper heating plate.

Fig. 22 is a sectional view illustrating an outline of a situation of hot-pressing the stacked structural body by a parallel plate method.

Fig. 23 is a schematic sectional view of a cured structural body.

Fig. 24 is a schematic sectional view of the cured structural body.

Fig. 25 is a schematic sectional view of a penetrated structural body.

Fig. 26 is a schematic sectional view of a re-interconnection structural body.

Fig. 27 is a schematic sectional view of semiconductor devices.

Fig. 28 shows SEM observation images of a cured product of Example 1; the upper image is an observed image magnified at a magnification of 200, and the lower image is an observed image magnified at a magnification of 1000.

Fig. 29 shows SEM observation images of a cured product of Comparative Example 1; the upper image is an observed image magnified at a magnification of 200, and the lower image is an observed image magnified at a magnification of 1000.

Fig. 30 is a sectional view illustrating an outline of a situation of pressing a structure having semiconductor chips and a thermosetting resin sheet located on the semiconductor chips.

MODE FOR CARRYING OUT THE INVENTION

[0014]

Hereinafter, the present invention will be described in detail by way of embodiments thereof. However, the present invention is not limited only to the embodiments.

[0015]

[Embodiment 1]

[0016]

(Sheet-formed Thermosetting Resin Composition 12 (hereinafter referred to also as "thermosetting resin sheet 12"))

A thermosetting resin sheet 12 will be described. As illustrated in Fig. 1, the thermosetting resin sheet 12 is in a sheet form.

[0017]

The thermosetting resin sheet 12 contains a filler. A value four times the average particle diameter of the filler is equal to or less than the thickness of the thermosetting resin sheet 12.

[0018]

Preferably, a value five times the average particle

diameter of the filler is equal to or less than the thickness of the thermosetting resin sheet 12. When the value five times the average particle diameter of the filler is equal to or less than the thickness of the thermosetting resin sheet 12, through holes can easily be made, by a laser, in a cured product obtained by curing the thermosetting resin sheet 12. Specifically, about through holes each defined by its laser-radiating-in opening, which is positioned closer to a light source of a laser, and its laser-radiating-out opening, which is opposite to the laser-radiating-in opening, it is possible to prevent the laser-radiating-out opening from becoming excessively smaller than the laser-radiating-in opening. Thus, the through holes can easily be made in the cured product.

The average particle diameter is calculated by the following method.

(Method for Calculating Average Particle Diameter)

A cross section of the thermosetting resin sheet 12 is observed with a scanning electron microscope (SEM) at an accelerating voltage of 5 kV or less at magnifications of 500, 10000, and 50000. Image software, such as software Image J, is then used to calculate the following three: a first average particle diameter of particles of the filler that have a size of 1 μm or more in a visual field of the cross section that is magnified at the magnification of 500; a second average particle diameter of particles of the filler that have a size of 0.1 μm

or more and less than 1 μm in a visual field thereof that is magnified at the magnification of 10000; and a third average particle diameter of particles of the filler that have a size less than 0.01 μm in a visual field thereof that is magnified at the magnification of 50000. On the basis of the first, second and third average particle diameters, the "average particle diameter" of the filler is calculated. The size of the area is set to that of the entire visual field in the monitor.

Because of the observations at the three magnifications, the average particle diameter can be calculated with good precision.

[0019]

When the thickness of the thermosetting resin sheet 12 is regarded as 100%, the maximum particle diameter of the filler is preferably 67% or less, more preferably 50% or less, even more preferably 40% or less. When the maximum particle diameter is regarded as 40% or less, damage impaired to a semiconductor chip can be relieved. In the meantime, when the thickness of the thermosetting resin sheet 12 is regarded as 100%, the maximum particle diameter of the filler is preferably 5% or more.

[0020]

The thickness of the thermosetting resin sheet 12 is preferably 10 μm or more, more preferably 20 μm or more, even more preferably 30 μm or more, in particular preferably 50 μm

or more. The thickness of the thermosetting resin sheet 12 may be 100 μm or more, 150 μm or more, or 180 μm or more. In the meantime, the thickness of the thermosetting resin sheet 12 is preferably 1000 μm or less, more preferably 300 μm or less, even more preferably 250 μm or less, even more preferably 200 μm or less.

[0021]

The average particle diameter of the filler is preferably 50 μm or less, more preferably 30 μm or less, even more preferably 25 μm or less, in particular preferably 20 μm or less. When the average particle diameter is 20 μm or less, through holes can easily be made, by a laser, in a cured product obtained by curing the thermosetting resin sheet 12. In the meantime, the average particle diameter of the filler is preferably 0.5 μm or more, more preferably 1 μm or more, even more preferably 3 μm or more.

[0022]

The maximum particle diameter of the filler is preferably 75 μm or less, more preferably 54 μm or less, even more preferably 20 μm or less. When the maximum particle diameter is 20 μm or less, damage imparted to a semiconductor chip can be relieved. In the meantime, the maximum particle diameter of the filler is preferably 0.5 μm or more, more preferably 3 μm or more.

[0023]

The filler is, for example, an inorganic filler.

[0024]

Examples of the inorganic filler include quartz glass, talc, silica (fused silica, crystalline silica, etc.), alumina, aluminum nitride, silicon nitride, and boron nitride. Among these inorganic fillers, silica and alumina are preferable, and silica is more preferable because the thermal expansion coefficient can be reduced well. Silica is preferably fused silica and more preferably spherical fused silica because of its excellent fluidity.

[0025]

The inorganic filler may be a filler treated (pre-treated) with a silane coupling agent. This treatment makes it possible to improve the inorganic filler in wettability with resin to heighten the filler in dispersibility therein.

[0026]

The content of the filler in the thermosetting resin sheet 12 is preferably 20% or more, more preferably 70% or more, even more preferably 74% or more by volume. In the meantime, the content of the filler is preferably 90% or less, more preferably 85% or less by volume. When the content is 90% or less by volume, the sheet 12 can gain a good irregularity-following performance.

[0027]

The content of the filler can be described by using "% by weight" as a unit. As a typical example, the content of

silica is described by using "% by weight" as a unit.

The specific gravity of silica is normally 2.2 g/cm^3. Therefore, a preferred range of the content (% by weight) of silica is as follows.

The content of silica in the thermosetting resin sheet 12 is preferably 81% by weight or more, and more preferably 84% by weight or more. The content of silica in the thermosetting resin sheet 12 is preferably 94% by weight or less, and more preferably 91% by weight or less.

[0028]

The specific gravity of alumina is normally 3.9 g/cm^3. Therefore, a preferred range of the content (% by weight) of alumina is as follows.

The content of alumina in the thermosetting resin sheet 12 is preferably 88% by weight or more, and more preferably 90% by weight or more. The content of alumina in the thermosetting resin sheet 12 is preferably 97% by weight or less, and more preferably 95% by weight or less.

[0029]

The thermosetting resin sheet 12 contains a thermosetting resin. Examples of the thermosetting resin include epoxy resin and phenolic resin.

[0030]

The epoxy resin is not particularly limited, and examples thereof include triphenyl methane type epoxy resin, cresol

novolak type epoxy resin, biphenyl type epoxy resin, modified bisphenol A type epoxy resin, bisphenol A type epoxy resin, bisphenol F type epoxy resin, modified bisphenol F type epoxy resin, dicyclopentadiene type epoxy resin, phenol novolak type epoxy resin, phenoxy resin, and other various epoxy resins. These epoxy resins may be used alone or in combination of two or more thereof.

[0031]

In order to secure reactivity, the epoxy resin is preferably a resin which has an epoxy equivalent of 150 to 250, and has a softening point or melting point of 50 to 130°C to be solid at room temperature. Out of species of the epoxy resin, more preferred are triphenylmethane type epoxy resin, cresol novolak type epoxy resin, and biphenyl type epoxy resin from the viewpoint of the reliability of the resin sheet. Preferred is bisphenol F type epoxy resin.

[0032]

The phenolic resin is not particularly limited as long as it initiates a curing reaction with an epoxy resin. Examples thereof include a phenol novolak resin, a phenolaralkyl resin, a biphenylaralkyl resin, a dicyclopentadiene-type phenolic resin, a cresol novolak resin, and a resol resin. These phenolic resins may be used either alone or in combination of two or more thereof.

[0033]

A phenolic resin having a hydroxyl equivalent of 70 to 250 and a softening point of 50°C to 110°C is preferably used from the viewpoint of reactivity with the epoxy resin. Among these phenolic resins, a phenol novolak resin can be preferably used from the viewpoint of its high curing reactivity. Further, a phenolic resin having low moisture absorption such as a phenolaralkyl resin and a biphenylaralkyl resin can also be suitably used from the viewpoint of its reliability.

[0034]

The total content of the epoxy resin and the phenolic resin in the thermosetting resin sheet 12 is preferably 5% or more by weight. When the total content is 5% or more by weight, the sheet can satisfactorily gain an adhesive strength onto the semiconductor chips and others. The total content of the epoxy resin and the phenolic resin in the thermosetting resin sheet 12 is preferably 40% or less by weight, more preferably 20% or less by weight. When the total content is 40% or less by weight, the sheet 12 can be controlled to be low in hygroscopicity.

[0035]

From the viewpoint of curing reactivity, the compounding ratio of the epoxy resin to the phenolic resin is preferably set so that the total amount of the hydroxy groups in the phenolic resin is 0.7 equivalent to 1.5 equivalents, and more preferably 0.9 equivalent to 1.2 equivalents per one equivalent of the epoxy groups in the epoxy resin.

[0036]

The thermosetting resin sheet 12 preferably contains a curing accelerator.

[0037]

The curing accelerator is not particularly limited as long as it promotes curing of the epoxy resin and the phenolic resin. Examples thereof include imidazole-based curing accelerators such as 2-methylimidazole (trade name; 2MZ), 2-undecylimidazole (trade name; C11-Z), 2-heptadecylimidazole (trade name; C17Z), 1,2-dimethylimidazole (trade name; 1.2DMZ), 2-ethyl-4-methylimidazole (trade name; 2E4MZ), 2-phenylimidazole (trade name; 2PZ), 2-phenyl-4-methylimidazole (trade name; 2P4MZ), 1-benzyl-2-methylimidazole (trade name; 1B2MZ), 1-benzyl-2-phenylimidazole (trade name; 1B2PZ), 1-cyanoethyl-2-methylimidazole (trade name; 2MZ-CN), 1-cyanoethyl-2-undecylimidazole (trade name; C11Z-CN), 1-cyanoethyl-2-phenylimidazolium trimellitate (trade name; 2PZCNS-PW), 2,4-diamino-6-[2'-methylimidazolyl-(1')]-ethyl-s-triazine (trade name; 2MZ-A), 2,4-diamino-6-[2'-undecylimidazolyl-(1')]-ethyl-s-triazine (trade name; C11Z-A), 2,4-diamino-6-[2'-ethyl-4'-methylimidazolyl-(1')]-ethyl-s-triazine (trade name; 2E4MZ-A),

2,4-diamino-6-[2'-metthylimidazolyl-(1')]-ethyl-s-triazine isocyanuric acid adduct (trade name; 2MA-OK), 2-phenyl-4,5-dihydroxymethylimidazole (trade name; 2PHZ-PW), and 2-phenyl-4-methyl-5-hydroxymethylimidazole (trade name; 2P4MZ-PW) (all of these compounds are manufactured by Shikoku Chemicals Corporation).

[0038]

Particularly preferred are imidazole curing accelerators since the accelerators restrain curing reaction at the kneading temperature. More preferred are 2-phenyl-4,5-dihydroxymethylimodazole, and 2,4-diamino-6-[2'-ethyl-4'-methylimidazolyl-(1')]ethyl-s-triazine; and even more preferred is 2-phenyl-4,5-dihydroxymethylimodazole.

[0039]

The content of the curing accelerator is preferably 0.2 parts or more, more preferably 0.5 parts or more, even more preferably 0.8 parts or more by weight for 100 parts by weight of the total of the epoxy resin and the phenolic resin. The content of the curing accelerator is preferably 5 parts or less, more preferably 2 parts or less by weight for 100 parts by weight of the total of the epoxy resin and the phenolic resin.

[0040]

The thermosetting resin sheet 12 may contain a thermoplastic resin. The thermoplastic resin is preferably an

elastomer.

[0041]

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 fluoro resin, a styrene-isobutylene-styrene triblock copolymer, and a methylmethacrylate-butadiene-styrene copolymer (MBS resin). These thermoplastic resins may be used alone or in combination of two or more thereof.

[0042]

The content of the thermoplastic resin(s) in the thermosetting resin sheet 12 is preferably 1% or more by weight. When the content is 1% or more by weight, softness and flexibility can be given to the sheet 12. The content of the thermoplastic resin(s) in the thermosetting resin sheet 12 is preferably 30% or less, more preferably 10% or less, even more preferably 5% or less by weight. When the content is 30% or less by weight, the sheet 12 can satisfactorily gain adhering strength to the semiconductor chips and others.

[0043]

The thermosetting resin sheet 12 may appropriately contain, besides the above-mentioned components, for example, a flame retardant component or a pigment.

[0044]

Examples of the flame retardant component include various types of metal hydroxides such as aluminum hydroxide, magnesium hydroxide, iron hydroxide, calcium hydroxide, tin hydroxide, and complex metal hydroxides; and a phosphazene compound. Among these flame retardant components, a phosphazene compound is preferable because of its excellent flame retardancy and strength after curing.

[0045]

The pigment is not particularly limited, and an example thereof is carbon black.

[0046]

The method for producing the thermosetting resin sheet 12 is not particularly limited, and is preferably a method of kneading the above-mentioned individual components (for example, the epoxy resin, phenolic resin, inorganic filler and curing accelerator) to yield a kneaded product, and working the product plastically into a sheet form. This method makes it possible to fill the inorganic filler highly and design the thermal expansion coefficient of the sheet 12 to a low value.

[0047]

Specifically, the epoxy resin, the phenolic resin, the

inorganic filler, the curing accelerator, etc. are melted and kneaded using a known kneader such as a mixing roll, a pressurizing kneader, and an extruder to prepare a kneaded product, and the obtained kneaded product is subjected to plastic working to form a sheet. As kneading conditions, the upper limit of the temperature is preferably 140°C or lower, and more preferably 130°C or lower. The lower limit of the temperature is preferably higher than or equal to the softening point of components described above, and is 30°C or higher, and preferably 50°C or higher, for example. The kneading time is preferably 1 to 30 minutes. The kneading is preferably performed under a reduced pressure condition (under a reduced pressure atmosphere), and the pressure under the reduced pressure condition is 1×10^{-4} to 0.1 kg/cm^2, for example.

[0048]

It is preferred to apply the plastic working to the kneaded product after the melt kneading in the state that the kneaded product keeps a high temperature without being cooled. The method for the plastic working is not particularly limited, and examples thereof include flat plate pressing, T-die extrusion, screw die extrusion, rolling, roll kneading, inflation extrusion, co-extrusion, and calendering methods. The plastic working temperature is preferably not lower than the respective softening points of the above-mentioned individual components, and is, for example, from 40 to 150°C,

preferably from 50 to 140°C, more preferably from 70 to 120°C, considering the thermosetting property and the moldability of the epoxy resin.

[0049]

It is also preferred to produce the thermosetting resin sheet 12 in an applying or coating manner. The thermosetting resin sheet 12 can be produced, for example, by producing an adhesive composition solution containing the above-mentioned individual components, applying the adhesive composition solution into a predetermined thickness onto a substrate separator to form a coating film, and then drying the coating film.

[0050]

A solvent used for the adhesive composition solution is not particularly limited, and is preferably an organic solvent in which the individual components can be evenly dispersed, kneaded or dispersed. Examples thereof include dimethylformamide, dimethylacetoamide, N-methylpyrrolidone, ketone solvents such as acetone, methyl ethyl ketone and cyclohexanone, toluene, and xylene.

[0051]

The substrate separator may be polyethylene terephthalate (PET), polyethylene or polypropylene, or a film or paper piece having a surface coated with a peeling agent such as a fluorine-containing peeling agent or a long-chain alkyl

acrylate peeling agent. The method for applying the adhesive composition solution is, for example, roll coating, screen coating or gravure coating. Conditions for drying the coating film are not particularly limited, and are, for example, as follows: a drying temperature of 70 to 160°C and a drying period of 1 to 5 minutes.

[0052]

(Method for Manufacturing Semiconductor Devices 54)

In a method of Embodiment 1, a fan-out wafer level package (WLP) is manufactured.

[0053]

As illustrated in Fig. 2, a stacked body 1 has a chip-temporarily-fixed body 11, a thermosetting resin sheet 12 located on the chip-temporarily-fixed body 11, and a separator 13 located on the thermosetting resin sheet 12. The stacked body 1 is arranged between a lower heating plate 41 and an upper heating plate 42.

[0054]

The chip-temporarily-fixed body 11 has a supporting plate 11a, a temporary fixing member 11b located on the supporting plate 11a, and semiconductor chips 14 located on the temporary fixing member 11b.

[0055]

The raw material of the supporting plate 11a is not particularly limited. Examples thereof include metallic

materials such as SUS; and plastic materials such as polyimides, polyamideimides, polyetheretherketones, and polyethersulfones.

[0056]

The raw material of the temporary fixing member 11b is not particularly limited, and is preferably a thermally-peelable pressure-sensitive adhesive such as a thermally-foamable pressure-sensitive adhesive since the adhesive is easily peelable.

[0057]

Each of the semiconductor chips 14 has a body part 14b, and electrode pads 14a located on the body part 14b. The raw material of the body part 14b is, for example, a semiconductor such as silicon. About the semiconductor chip 14, both of its surfaces are defined by its first main surface, and its second main surface which is opposite to the first main surface. The electrode pads 14a are positioned on the second main surface. The second main surface contacts the temporary fixing member 11b.

[0058]

The separator 13 may be preferably, for example, a polyethylene terephthalate (PET) film. The separator 13 is preferably a separator subjected to release treatment since the thermosetting resin sheet 12 is easily peelable from the separator 13.

[0059]

As illustrated in Fig. 3, the lower heating plate 41 and the upper heating plate 42 are used to hot-press the stacked body 1 by a parallel plate method to form a sealed body 51.

[0060]

The hot-pressing temperature is preferably 70°C or higher, more preferably 80°C or higher. The hot-pressing temperature is preferably 170°C or lower, more preferably 150°C or lower, even more preferably 100°C or lower. The pressure at which the stacked body 1 is hot-pressed is preferably 1.0 MPa or more, more preferably 1.5 MPa or more. The pressure at which the stacked body 1 is hot-pressed is preferably 10 MPa or less, more preferably 8 MPa or less. The period for the hot-pressing is preferably 0.3 minute or longer, more preferably 1 minute or longer. The period for the hot-pressing is preferably 60 minutes or shorter, more preferably 10 minutes or shorter.

[0061]

The hot-pressing is performed preferably in a reduced-pressure atmosphere. The hot-pressing in the reduced-pressure atmosphere makes it possible to reduce voids in the stacked body and plug up irregularities thereof satisfactorily. The pressure in the reduced-pressure atmosphere is, for example, from 0.1 to 5 kPa, or 0.1 to 100 Pa.

[0062]

The sealed body 51 has the semiconductor chips 14, and the thermosetting resin sheet 12 which covers the semiconductor chips 14. The sealed body 51 contacts the temporary fixing member 11b and the separator 13.

[0063]

As illustrated in Fig. 4, the separator 13 is peeled from the sealed body 51.

[0064]

Next, the sealed body 51 is heated to cure the thermosetting resin sheet 12, thereby forming a cured body 52.

[0065]

The heating temperature is preferably 100°C or higher, more preferably 120°C or higher. In the meantime, the upper limit of the heating temperature is preferably 200°C or lower, more preferably 180°C or lower. The heating period is preferably 10 minutes or longer, more preferably 30 minutes or longer. In the meantime, the upper limit of the heating period is preferably 180 minutes or shorter, more preferably 120 minutes or shorter. The sealed body 51 is heated preferably in a pressurized atmosphere. The pressure is preferably 0.1 MPa or more, more preferably 0.5 MPa or more. In the meantime, the upper limit of the pressure is 10 MPa or less, more preferably 5 MPa or less.

[0066]

As illustrated in Fig. 5, the cured body 52 has the

semiconductor chips 14, and a protective member 21 covering the semiconductor chips 14. About the cured body 52, both of its surfaces are defined by its surface on which a film is to be formed, on which the semiconductor chips 14 are positioned, and its surface opposite to the surface on which a film is to be formed.

[0067]

As illustrated in Fig. 6, the temporary fixing member 11b is heated to be lowered in adhesive strength, and then this temporary fixing member 11b is peeled from the cured body 52. The temperature at which the temporary fixing member 11b is heated is preferably 175°C or higher, more preferably 180°C or higher. The upper limit of the temperature at which the temporary fixing member 11b is heated is, for example, 200°C.

[0068]

As illustrated in Fig. 7, the surface of the cured body 52 that is opposite to the surface on which a film is to be formed may be abraded. The abrasion makes it possible to decrease the cured body 52 from being warped. The method for the abrasion is, for example, a grinding method using a grinding stone rotatable at a high speed.

[0069]

As illustrated in Fig. 8, a buffer coat film 61 is formed on the surface on which a film is to be formed. The raw material of the buffer coat film 61 may be, for example, a photosensitive

polyimide or a photosensitive polybenzoxazole (PBO). The method for forming the buffer coat film 61 may be, for example, a spin coating method, a die coating method, or a method of locating a dry film on the surface on which a film is to be formed.

[0070]

As illustrated in Fig. 9, a mask 62 is located on the buffer coat film 61. Next, from a light source 91 arranged over the buffer coat film 61, exposure light is radiated to photosensitize the buffer coat film 61.

[0071]

Next, as illustrated in Fig. 10, openings 61A and openings 61B are made in the buffer coat film 61 to expose predetermined portions of the protective member 21 and the electrode pads 14a.

[0072]

As illustrated in Fig. 11, a laser is radiated to make through holes 71 in the protective member 21. The through holes 71 penetrate the protective member 21 in the thickness direction thereof.

[0073]

As illustrated in Fig. 12, a metal is filled into the through holes 71 to form through electrodes 72. The through electrodes 72 extend in the thickness direction of the protective member 21. Examples of the filled metal include Cu, Ag, Au, Sn, and any eutectic solder. The eutectic solder may be, for example, Sn-Ag eutectic solder or Sn-Ag-Cu eutectic

solder.

[0074]

Next, a seed layer is formed on the buffer coat film 61, the electrode pads 14a, and the through electrodes 72.

[0075]

As illustrated in Fig. 13, a resist 63 is formed on the seed layer.

[0076]

As illustrated in Fig. 14, a plating pattern 64 is formed on the seed layer by a plating method such as electrolytic copper plating.

[0077]

As illustrated in Fig. 15, the resist 63 is removed, and then the seed layer is etched to complete the formation of re-interconnections 65 and re-interconnections 75.

[0078]

As illustrated in Fig. 16, a protective film 66 is formed on the re-interconnections 65 and the re-interconnections 75. The raw material of the protective film 66 may be, for example, a photosensitive polyimide or a photosensitive polybenzoxazole (PBO).

[0079]

As illustrated in Fig. 17, openings are made in the protective film 66 to expose the re-interconnections 65 and the re-interconnections 75 which are positioned beneath the

protective film 66. In this way, on the cured body 52, the formation of a re-interconnection layer 69 including the re-interconnections 65 and the re-interconnections 75 is completed. In this way, a re-interconnection body 53 is yielded. The re-interconnection body 53 has the semiconductor chips 14, the protective member 21 arranged around the semiconductor chips 14, the through electrodes 72 extending in the thickness direction of the protective member 21 and penetrating the protective member 21, and the re-interconnection layer 69 located on the semiconductor chips 14.

[0080]

As illustrated in Fig. 18, electrodes (UBM: under bump metal) 67 are formed on the re-interconnections 65. Electrodes 77 are also formed on the re-interconnections 75.

[0081]

As illustrated in Fig. 19, bumps 68 are formed on the electrodes 67. The bumps 68 are electrically connected through the electrodes 67 and the re-interconnections 65 to the electrode pads 14a. Bumps 78 are also formed on the electrodes 77. The bumps 78 are electrically connected through the electrodes 77 and the re-interconnections 75 to the through electrodes 72.

[0082]

As illustrated in Fig. 20, the re-interconnection body 53 is made into individual pieces (or diced) to yield

semiconductor devices 54.

[0083]

As described above, the method of Embodiment 1 for manufacturing the semiconductor devices 54 includes the step of covering the semiconductor chips 14 with the thermosetting resin sheet 12. The step of covering the semiconductor chips 14 with the thermosetting resin sheet 12 includes the step of pressing the stacked body 1.

[0084]

[Embodiment 2]

As illustrated in Fig. 21, a stacked structural body 2 has a chip-mounted wafer 21, a thermosetting resin sheet 12 located on the chip-mounted wafer 21, and a separator 13 located on the thermosetting resin sheet 12. The stacked structural body 2 is arranged between a lower heating plate 41 and an upper heating plate 42.

[0085]

The chip-mounted wafer 21 has a semiconductor wafer 31, and semiconductor chips 14 flip-chip-mounted (or flip-chip-bonded) onto the semiconductor wafer 31. The chip-mounted wafer 21 further has an underfill material 15 sandwiched between the semiconductor wafer 31 and the semiconductor chips 14.

[0086]

Each of the semiconductor chips 14 has a body part 14b,

and bumps 14c located on the body part 14b. The raw material of the body part 14b is, for example, a semiconductor such as silicon. About the semiconductor chip 14, both of its surfaces are defined by its first main surface, and its second main surface that is opposite to the first main surface. The bumps 14c are positioned on the second main surface.

[0087]

The semiconductor wafer 31 has a wafer part 31a, through electrodes 31b extending in the thickness direction of the wafer part 31a, and electrodes 31c arranged on the through electrodes 31b. The raw material of the wafer part 31a is, for example, a semiconductor such as silicon. About the semiconductor wafer 31, both of its surfaces are defined by its electrode surface and its rear surface opposite to the electrode surface. The electrodes 31c are positioned on the electrode surface of the semiconductor wafer 31.

[0088]

The semiconductor chips 14 are electrically connected through the bumps 14c and the electrodes 31c to the semiconductor wafer 31.

[0089]

As illustrated in Fig. 22, the lower heating plate 41 and the upper heating plate 42 are used to hot-press the stacked structural body 2 by a parallel plate method, thereby forming a sealed structural body 71. Preferred conditions for the

hot-pressing are similar to the hot-pressing conditions described in Embodiment 1. The hot-pressing is performed preferably in a reduced-pressure atmosphere. Preferred conditions for the pressure reduction are similar to the pressure reduction conditions described in Embodiment 1.

[0090]

The sealed structural body 71 has the semiconductor wafer 31, the semiconductor chips 14 flip-chip-mounted on the semiconductor wafer 31, and the thermosetting resin sheet 12 covering the semiconductor chips 14. The sealed structural body 71 contacts the separator 13.

[0091]

The separator 13 is peeled from the sealed structural body 71.

[0092]

The sealed structural body 71 is heated to cure the thermosetting resin sheet 12, thereby forming a cured structural body 72. Preferred conditions for the heating are similar to the heating conditions described in Embodiment 1.

[0093]

As illustrated in Fig. 23, the cured structural body 72 has the semiconductor wafer 31, the semiconductor chips 14 flip-chip-mounted on the semiconductor wafer 31, and the protective member 21 covering the semiconductor chips 14. About the cured structural body 72, both of its surfaces are

defined by its wafer surface on which the semiconductor wafer 31 is positioned, and its surface opposite to the wafer surface.

[0094]

As illustrated in Fig. 24, the surface opposite to the wafer surface may be abraded.

[0095]

As illustrated in Fig. 25, the wafer surface is abraded to yield a through structural body 73. The through structural body 73 has a through wafer 32, the semiconductor chips 14 flip-chip-mounted on the through wafer 32, and the protective member 21 arranged around the semiconductor chips 14. The through wafer 32 has a main part 32a made in a disc form, the through electrodes 31b extending in the thickness direction of the main part 32a and penetrating the main part 32a, and the electrodes 31c located on the through electrodes 31b. About the through wafer 32, both of its surfaces are defined by its surface on which a layer is to be formed, on which the through electrodes 31b are positioned, and its surface opposite to the surface on which a layer is to be formed.

[0096]

As illustrated in Fig. 26, for example, a semiadditive method is used to form a re-interconnection layer 81 on the surface on which a layer is to be formed, thereby forming a re-interconnection structural body 74. The re-interconnection layer 81 has re-interconnections 82. Next,

bumps 83 are formed on the re-interconnection layer 81. The bumps 83 are electrically connected through the re-interconnections 82, the electrodes 31c and the through electrodes 31b to the bumps 14c. The re-interconnection structural body 74 has the through wafer 32, the semiconductor chips 14 flip-chip-mounted on the through wafer 32, the protective member 21 arranged around the semiconductor chips 14, and the re-interconnection layer 81 located on the surface on which a layer is to be formed.

[0097]

As illustrated in Fig. 27, the re-interconnection structural body 74 is made into individual pieces (or diced) to yield semiconductor devices 75.

[0098]

(Modified Example 1)

In Embodiment 2, about the chip-mounted wafer 21, the underfill material 15 is filled into the gap between the semiconductor chips 14 and the semiconductor wafer 31. In Modified Example 1, however, the underfill material 15 is not filled into the gap between the semiconductor chips 14 and the semiconductor wafer 31.

[0099]

As described above, the method of Embodiment 2 for manufacturing the semiconductor devices 75 includes the step of covering the semiconductor chips 14 with the thermosetting

resin sheet 12. The step of covering the semiconductor chips 14 with the thermosetting resin sheet 12 includes the step of pressing the stacked structural body 2.

EXAMPLES

[0100]

Hereinafter, preferred working examples of the present invention will be demonstratively described in detail. However, about raw materials, blend amounts and other matters that are described in the examples, the scope of the present invention is not limited only to such matters unless the matters are in particular restrictedly described.

[0101]

Components used to produce resin sheets are described.

Epoxy resin 1: YSLV-80XY, manufactured by Nippon Steel Chemical Co., Ltd. (bisphenol F type epoxy resin; epoxy equivalent: 191 g/eq., and softening point: 80°C)

Epoxy resin 2: Epikote 828, manufactured by Mitsubishi Chemical Corporation (bisphenol A type epoxy resin; epoxy equivalent: 185 g/eq.)

Phenolic resin: MEH-7500-3S, manufactured by Meiwa Plastic Industries, Ltd. (hydroxyl equivalent: 107 g/eq., and softening point: 83°C)

Curing accelerator: 2PHZ-PW, manufactured by Shikoku Chemicals Corporation

(2-phenyl-4,5-dihydroxymethylimidazole)

Silica filler B: FB-9454, manufactured by Denka Co., Ltd. (spherical fused silica; average particle diameter: 20 μm, and maximum particle diameter: 54 μm)

Silica filler D: 5SDC, manufactured by Denka Co., Ltd. (spherical fused silica; average particle diameter: 5 μm, and maximum particle diameter: 20 μm)

Silica filler E: 3SDC, manufactured by Denka Co., Ltd. (spherical fused silica; average particle diameter: 3 μm, and maximum particle diameter: 10 μm)

Silica filler G: MSR-8040, manufactured by TATSUMORI LTD. (spherical fused silica; average particle diameter: 11 μm, and maximum particle diameter: 45 μm)

Alumina filler I: AL-17-1, manufactured by Showa Denko K.K. (alumina filler; average particle diameter: 60 μm)

Alumina filler J: DAW-45, manufactured by Denka Co., Ltd. (alumina filler; average particle diameter: 43 μm)

Silane coupling agent: KBM-403, manufactured by Shin-Etsu Chemical Co., Ltd.
(3-glycidoxypropyltrimethoxysilane)

Carbon black: #20, manufactured by Mitsubishi Chemical Corporation

[0102]

[Production of Resin Sheets]

In accordance with a blend ratio shown in Table 1,

individual components were blended together, and then melt-kneaded with a roll kneader at 60 to 120°C under a reduced pressure condition (0.01 kg/cm^2) for 10 minutes to prepare a kneaded product. Next, the kneaded product was made into the form of a sheet by a flat plate pressing method. In this way, resin sheets each having a length of 200 mm, a width of 230 mm, and a thickness shown in Table 1 were produced.

[0103]

[Table 1]

		Comparative Example 1	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8	Example 9	Example 10	Example 11
Blend ratio (parts by weight)	Epoxy resin 1	206.3	206.3	206.3	206.3	257.9	206.3	206.3	206.3	206.3	206.3	206.3	206.3
	Epoxy resin 2	199.8	199.8	199.8	199.8	249.8	199.8	199.8	199.8	199.8	199.8	199.8	199.8
	Phenolic resin	184.9	184.9	184.9	184.9	231.2	184.9	184.9	184.9	184.9	184.9	184.9	184.9
	Curing accelerator	5.9	5.9	5.9	5.9	7.4	5.9	5.9	5.9	5.9	5.9	5.9	5.9
	Silica filler B	-	-	4400.0	-	-	4400.0	4400.0	4400.0	4400.0	4400.0	4400.0	-
	Silica filler D	-	-	-	4400.0	-	-	-	-	-	-	-	-
	Silica filler E	-	-	-	-	4250.0	-	-	-	-	-	-	-
	Silica filler G	-	-	-	-	-	-	-	-	-	-	-	4350.0
	Alumina filler I	4400.0	-	-	-	-	-	-	-	-	-	-	-
	Alumina filler J	-	4400.0	-	-	-	-	-	-	-	-	-	-
	Silane coupling agent	4.4	4.4	4.4	4.4	4.3	4.4	4.4	4.4	4.4	4.4	4.4	4.4
	Carbon black	3.0	3.0	3.0	3.0	3.8	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Total		5004.4	5004.4	5004.4	5004.4	5004.3	5004.4	5004.4	5004.4	5004.4	5004.4	5004.4	4954.4
Filler content (% by volume) in resin sheet		88	88	88	88	88	88	88	88	88	88	88	88
Sheet thickness (μm)		200	200	200	200	200	80	100	300	500	1000	220	200
Average particle diameter of silica filler (μm)		60	43	20	5	3	20	20	20	20	20	20	11
Maximum particle diameter of silica filler (μm)		-	-	54	20	10	54	54	54	54	54	54	45
Relationship between sheet thickness and average particle diameter		"Sheet thickness" = 3.3 × "average particle diameter"	"Sheet thickness" = 4.7 × "average particle diameter"	"Sheet thickness" = 10 × "average particle diameter"	"Sheet thickness" = 40 × "average particle diameter"	"Sheet thickness" = 66.7 × "average particle diameter"	"Sheet thickness" = 4 × "average particle diameter"	"Sheet thickness" = 5 × "average particle diameter"	"Sheet thickness" = 15 × "average particle diameter"	"Sheet thickness" = 25 × "average particle diameter"	"Sheet thickness" = 50 × "average particle diameter"	"Sheet thickness" = 11 × "average particle diameter"	"Sheet thickness" = 18.2 × "average particle diameter"
Ratio of maximum particle diameter to sheet thickness		-	-	0.27	0.10	0.05	0.68	0.54	0.18	0.11	0.05	0.25	0.23
Evaluations	Chip cracking	×	△	○	○	○	○	○	○	○	○	○	○
	Through hole state	×	○	○	○	○	○	○	○	○	○	○	○

[0104]

[Evaluation 1: chip cracking]

A thermally-peelable sheet (REVALPHA "3195V," manufactured by Nitto Denko Corporation; length: 200 mm, width: 230 mm, and thickness: 100 μm) was laminated on a glass plate (TEMPAX glass; length: 200 mm, width: 230 mm, and thickness: 1.1 mm). Next, plural silicon chips (length: 7 mm, width: 7 mm, and thickness: 200 μm) were arranged on the thermally-peelable sheet. In this way, a chip-temporarily-fixed body was yielded which was composed of the glass plate, the thermally-peelable sheet located on the glass plate, and the silicon chips located on the thermally-peelable sheet.

[0105]

Next, a resin sheet was arranged on the chip-temporarily-fixed body. In this way, a stacked body was yielded which was composed of the chip-temporarily-fixed body and the resin sheet located on the chip-temporarily-fixed body.

[0106]

Next, using a parallel plate press machine (manufactured by Mikado Technos Co., Ltd.), the stacked body was pressed in a vacuum atmosphere by a parallel plate method at 90°C and a pressing pressure of 1.0 MPa for 120 seconds. In this way, a sealed body (which was composed of the silicon chips and the resin sheet covering the silicon chips) was yielded.

[0107]

A cross section of the sealed body was observed. When the silicon chips were not cracked, the resin sheet was judged to be ○. Alternatively, when the silicon chips were not cracked but particles of the filler were recognized which had a diameter close to the thickness of the resin positioned on the silicon chips, so that it was feared that the silicon chips would be cracked, the resin sheet was judged to be △; or when the silicon chips were cracked, the resin sheet was judged to be ×. The results are shown in Table 1.

[0108]

[Evaluation 2: through hole state]

Using a parallel plate press machine (manufactured by Mikado Technos Co., Ltd.), a resin sheet was pressed in a vacuum atmosphere by a parallel plate method at 90°C and a pressing pressure of 1.0 MPa for 120 seconds. In this way, the thickness of the resin sheet was adjusted to 80% of the original thickness thereof. Next, the resin sheet was kept at 150°C for 60 minutes to cure.

[0109]

A laser was radiated onto a cured product obtained by curing the resin sheet under conditions shown in Table 2. In this way, through holes each having a diameter of 50 μm were made in the cured product. Next, the cured product was observed through a microscope. When it was verified that circular

through holes were made, the resin sheet was judged to be ○ (see Fig. 28). Alternatively, when circular through holes were not obtained by effect of the filler, the resin sheet was judged to be × (see Fig. 29). The results are shown in Table 1.

[0110]

[Table 2]

Apparatus	LAVIA 1000W, manufactured by Sumitomo Heavy Industries, Ltd.
Kind of laser	CO_2
Oscillator power	60 W
Power of laser radiation part	1.5 W
Frequency	500 HZ
Spot diameter	0.1 mm

CLAIMS

1. A resin composition, comprising a filler,

a value four times the average particle diameter of the filler being equal to or less than the thickness of the resin composition.

2. The resin composition according to claim 1, which is in a sheet form.

3. A semiconductor device manufacturing method, comprising the step of covering a semiconductor chip with the resin composition recited in claim 1 or 2.

4. A semiconductor device, obtained by the method recited in claim 3.