

DESCRIPTION

Title of Invention

SEMICONDUCTOR DEVICE, AND METHOD FOR MANUFACTURING SAME

5 Technical Field

[0001] The present disclosure relates to a semiconductor device and a method for manufacturing the same.

Background Art

10 [0002] A stacked MCP (Multi Chip Package) having a configuration in which semiconductor elements are stacked in multiple stages has become widespread in association with the multi-functionalization of electronic devices. A film-like adhesive is used in the mounting of the semiconductor element. As an example of multistage stacked packages using a film-like adhesive, a wire-embedded type package is
15 mentioned. This refers to a package in which a wire connected to a semiconductor element to be pressure-bonded is pressure-bonded by using a high-flow film-like adhesive while covering the wire with the adhesive, and is mounted on memory packages and the like for mobile phones and mobile audio devices.

20 [0003] As one of important properties required in the semiconductor devices, connection reliability is mentioned. In order to improve connection reliability, film-like adhesives in which properties such as heat resistance, moisture resistant, and reflow resistance are taken into consideration have been developed. For example, Patent Literature 1
25 discloses an adhesive sheet which contains a resin containing a high-molecular-weight component and a thermosetting component

containing an epoxy resin as a main component, and a filler and has a thickness of 10 to 250 μm . Patent Literature 2 discloses an adhesive composition which contains a mixture containing an epoxy resin and a phenolic resin and an acrylic copolymer.

5 [0004] The connection reliability of the semiconductor device also greatly depends on whether or not a semiconductor element can be mounted without voids being generated on an adhesive surface. Therefore, attempts have been made to use a high-flow film-like adhesive so that a semiconductor element can be pressure-bonded
10 without voids being generated, to use a film-like adhesive having a low melt viscosity so that generated voids can be eliminated by a sealing step of a semiconductor element, and the like. Patent Literature 3 discloses an adhesive sheet having a low viscosity and a low tack strength.

15 **Citation List**

Patent Literature

[0005] Patent Literature 1: International Publication WO 2005/103180

Patent Literature 2: Japanese Unexamined Patent Publication No. 2002-220576

20 Patent Literature 3: Japanese Unexamined Patent Publication No. 2009-120830

Summary of Invention

Technical Problem

25 [0006] Incidentally, when the size of the semiconductor chip (semiconductor element) is small, power to be applied per unit area at the time of thermocompression bonding is too large, and there is a

concern that the adhesive film collapses and electric failure occurs. Furthermore, when multistage stacking is conducted using an FOD (Film Over Die) that is a chip-embedded type adhesive film or an FOW (Film Over Wire) that is a wire-embedded type adhesive film, there are problems in that peeling-off of a chip, bowing of the entire package, and the like occur due to the residual stress of the chip. Further, in the case of using FOD or FOW, the embeddability of a chip and/or a wire tends to be deteriorated. According to this, there is a problem in that the deterioration of embeddability leads to peeling-off of FOD or FOW and an increase in cracks at the time of reflow.

[0007] An object of the present disclosure is to provide a semiconductor device having a useful configuration for achieving an improvement in embeddability of a film-like adhesive composed of a thermosetting resin composition and reducing the entire bowing and a manufacturing method therefor.

Solution to Problem

[0008] A method for manufacturing a semiconductor device of the present disclosure includes a step of preparing a substrate having a recess, a step of disposing a first semiconductor element in the recess of the substrate, a step of preparing a laminate of a film-like adhesive composed of a thermosetting resin composition and a second semiconductor element by dicing, a step of pressing the laminate against the substrate so that the film-like adhesive covers a region including the recess in the substrate and the first semiconductor element is embedded in the film-like adhesive, and a step of sealing the first semiconductor element with a cured product of the film-like adhesive by heating the

film-like adhesive, in which an area of the recess of the substrate is smaller than an area of the second semiconductor element.

[0009] In the above-described manufacturing method, since the laminate is prepared by dicing, the area of the second semiconductor element and the area of the film-like adhesive are substantially the same. The area (opening area) of the recess being smaller than the area of the film-like adhesive means that the film-like adhesive is larger than the opening area of the recess. Such a configuration is useful for achieving an improvement in embeddability of the film-like adhesive composed of a thermosetting resin composition and reducing the entire bowing. That is, the amount of a second semiconductor element Wb embedded can be decreased from a state illustrated in FIG. 4(b) (a state where a film-like adhesive 15P abuts on a surface of a first semiconductor element Wa) to a state illustrated in FIG. 4(c) (a state where the first semiconductor element Wa is embedded in the film-like adhesive 15P). According to this, it is speculated that the residual stress of the first and second semiconductor elements can be decreased, and the bowing of the entire semiconductor device can be suppressed. On the other hand, in a case where the first semiconductor element Wa is disposed on a flat substrate 10B having no recess as illustrated in FIGS. 6(a) and 6(b), it is necessary to increase the amount of the second semiconductor element Wb embedded as compared to the states illustrated in FIGS. 4(b) and 4(c).

[0010] Incidentally, the first semiconductor element is disposed in a recess having a smaller opening area than the area of the film-like adhesive, this is then embedded in the film-like adhesive (see FIG. 4(c)),

and thereby the distance between the first semiconductor element and the second semiconductor element can be secured even if the thickness of the film-like adhesive is not excessively increased as compared to a case where the first semiconductor element is disposed on such a flat substrate having no recess (see FIG. 6(b)), and contact between both semiconductor elements can be sufficiently suppressed. The thickness of the film-like adhesive is sufficient to be set, for example, in a range of 60 to 150 μm according to the thickness of the first semiconductor element to be embedded, or the like.

[0011] The area of the recess is preferably 30 to 80% with respect to the area of the second semiconductor element (the area of the film-like adhesive) and the depth of the recess is preferably 10 to 30% with respect to the height of the first semiconductor element from the viewpoint of the embeddability of the film-like adhesive into the recess.

Incidentally, the height of the first semiconductor element described herein means a height from the bottom surface of the recess to the upper surface of the first semiconductor element (for example, including the thickness of the adhesive for pressure-bonding the first semiconductor element to the substrate).

[0012] As the film-like adhesive, a thermosetting resin composition having a shear viscosity of 5000 Pa·s or less at any temperature of 60°C to 150°C is preferably used. From the viewpoint of suppressing the bowing of a semiconductor device to be manufactured, the thickness of the substrate (excluding a recess part) is, for example, 90 to 140 μm .

[0013] In the case of using a substrate having a circuit pattern on a surface thereof as the substrate, the manufacturing method of the

present disclosure may further include a first wire bonding step of electrically connecting the first semiconductor element and the circuit pattern to each other. Furthermore, in this case, the manufacturing method of the present disclosure may further include a second wire bonding step of electrically connecting the second semiconductor element and the circuit pattern to each other and a step of sealing the second semiconductor element and the second wire with a resin composition.

[0014] The manufacturing method of the present disclosure may further include a step of stacking a third semiconductor element above the second semiconductor element. In the manufacturing method of the present disclosure, the first semiconductor element may be sealed with a cured product of the film-like adhesive by heating the film-like adhesive under a pressurized atmosphere.

[0015] A semiconductor device of the present disclosure includes a substrate having a recess, a first semiconductor element disposed in the recess, a first sealing layer disposed to cover a region including the recess in the substrate and sealing the first semiconductor element, and a second semiconductor element disposed to cover a surface in the first sealing layer opposite to the side of the substrate, the first sealing layer is composed of a cured product of a film-like adhesive composed of a thermosetting resin composition, and an area of the recess is smaller than an area of the second semiconductor element. Such a configuration is useful for achieving an improvement in embeddability of the film-like adhesive composed of a thermosetting resin composition and reducing the entire bowing.

[0016] The semiconductor device of the present disclosure may further include a circuit pattern formed on a surface of the substrate and a first wire electrically connecting the first semiconductor element and the circuit pattern to each other. The semiconductor device of the present disclosure may further include a second wire electrically connecting the second semiconductor element and the circuit pattern to each other and a second sealing layer sealing the second semiconductor element and the second wire. The semiconductor device of the present disclosure may further include a third semiconductor element stacked above the second semiconductor element.

Advantageous Effects of Invention

[0017] According to the present disclosure, there are provided a semiconductor device having a useful configuration for achieving an improvement in embeddability of a film-like adhesive composed of a thermosetting resin composition and reducing the entire bowing and a manufacturing method therefor.

Brief Description of Drawings

[0018] FIG. 1 is a cross-sectional view schematically illustrating an embodiment of a semiconductor device of the present disclosure.

FIG. 2 is a cross-sectional view schematically illustrating an example of a laminate including a film-like adhesive and a second semiconductor element.

FIG. 3(a) is a cross-sectional view schematically illustrating an example of a substrate having a recess, and FIG. 3(b) is a plan view of the substrate illustrated in FIG. 3(a).

FIGS. 4(a) to 4(c) are cross-sectional views schematically

illustrating a process of manufacturing the semiconductor device illustrated in FIG. 1.

FIGS. 5(a) to 5(e) are cross-sectional views schematically illustrating a process of manufacturing the laminate including the film-like adhesive and the second semiconductor element.

FIGS. 6(a) and 6(b) are cross-sectional views schematically illustrating a step of embedding a semiconductor element disposed on a substrate having no recess with a film-like adhesive.

Description of Embodiments

[0019] Hereinafter, embodiments of the present disclosure will be specifically described with reference to the drawings. Incidentally, the present invention is not limited to the following embodiments.

[0020] <Semiconductor device>

FIG. 1 is a cross-sectional view schematically illustrating a semiconductor device of the present embodiment. A semiconductor device 100 illustrated in this drawing includes a substrate 10 having a recess 10a, a first semiconductor element Wa disposed in the recess 10a, a first sealing layer 15 sealing the first semiconductor element Wa, a second semiconductor element Wb disposed above the first semiconductor element Wa, and a second sealing layer 25 sealing the second semiconductor element Wb. The first sealing layer 15 is composed of a cured product of a film-like adhesive 15P (see FIG. 2). Incidentally, as illustrated in FIG. 2, the film-like adhesive 15P and the second semiconductor element Wb have substantially the same size. A laminate 20 illustrated in FIG. 2 includes the film-like adhesive 15P and the second semiconductor element Wb and is also referred to as an

adhesive-attached semiconductor chip. The laminate 20 is prepared through a dicing step and a pickup step as described below (see FIG. 5).

[0021] As illustrated in FIG. 3(a), the recess 10a of the substrate 10 is configured by a bottom surface 10b and a side surface 10c extending a direction of a surface 10F (surface other than the recess 10a) of the substrate 10 from the bottom surface 10b. As illustrated in FIG. 3(b), the shape of the recess 10a in plan view is a rectangular shape (square or rectangle). The thickness of the substrate 10 (thickness T illustrated in FIG. 3(a)) is, for example, 90 to 140 μm and may be 100 to 130 μm from the viewpoint of suppressing the bowing of the semiconductor device 100 to be manufactured. Incidentally, the shape of the recess 10a is not limited to a rectangular shape and may be a rounded shape such as a circular shape or an elliptical shape. Furthermore, the side surface of the recess 10a may be formed, for example, in a tapered shape from the viewpoint of improving the embeddability of the film-like adhesive.

[0022] The first semiconductor element Wa is disposed on the bottom surface 10b of the recess 10a. The size of the bottom surface 10b of the recess 10a is larger than the size of the first semiconductor element Wa. The shape of the first semiconductor element Wa in plan view is, for example, a rectangular shape (square or rectangle). The length of one side of the first semiconductor element Wa is, for example, 5 mm or less and may be 1 to 5 mm or 3 to 5 mm. From the viewpoint of highly achieving both suppression of the bowing of the semiconductor device 100 and the embeddability of the first sealing layer 15, the gap between the first semiconductor element Wa and the side surface 10c of

the recess 10a is preferably 1.2 to 5 mm, more preferably 2 to 5 mm, and further preferably 4 to 5 mm.

[0023] The depth (depth D illustrated in FIG. 3(a)) of the recess 10a is, for example, 5 to 60 μm and may be 10 to 50 μm or 20 to 40 μm from the viewpoint of the embeddability of the film-like adhesive into the recess 10a. The depth of the recess 10a is preferably 10 to 30% and more preferably 15 to 25% with respect to the height of the first semiconductor element Wa (the height from the bottom surface 10b of the recess 10a to the upper surface of the first semiconductor element Wa) from the viewpoint of the embeddability of the film-like adhesive into the recess 10a.

[0024] In the present embodiment, the first semiconductor element Wa is a controller chip for driving the semiconductor device 100. The thickness of the first semiconductor element Wa is, for example, 10 to 170 μm and may be 20 to 100 μm . Incidentally, the thickness of the second semiconductor element Wb is, for example, 20 to 400 μm and may be 50 to 200 μm .

[0025] From the viewpoint of the embeddability of the film-like adhesive into the recess 10a, as illustrated in FIG. 1, the size of the recess 10a is smaller than the size of the second semiconductor element Wb. More specifically, the opening area of the recess 10a in the surface 10F of the substrate 10 is smaller than the area of the second semiconductor element Wb. Further, when the laminate 20 (indicated by dashed line in FIG. 3(b)) is disposed on the substrate 10 to cover the recess 10a so that the film-like adhesive 15P faces downward, an edge portion 15a of the film-like adhesive 15P abuts on the surface 10F of the

substrate 10. The area (the opening area in the surface 10F) of the recess 10a is preferably 30 to 80% and more preferably 50 to 75% with respect to the area of the second semiconductor element Wb (the area of the film-like adhesive 15P) from the viewpoint of the embeddability of the film-like adhesive 15P into the recess 10a.

[0026] The shape of the second semiconductor element Wb in plan view is, for example, a rectangular shape (square or rectangle). The length of one side of the second semiconductor element Wb is, for example, 20 mm or less and may be 2 to 20 mm or 7 to 20 mm.

[0027] As illustrated in FIG. 1, the substrate 10 has circuit patterns C1 and C2. The circuit pattern C1 is formed on the bottom surface 10b of the recess 10a. The circuit pattern C2 is formed on the surface 10F of the substrate 10. The first semiconductor element Wa is pressure-bonded on the circuit pattern C1 via an adhesive 5 and connected to the circuit pattern C2 via a first wire 11. The second semiconductor element Wb is mounted on the substrate 10 via the first sealing layer 15 so that the entire first semiconductor element Wa and a part of the circuit pattern C2 are covered. The second semiconductor element Wb is connected to the circuit pattern C2 via a second wire 12 and sealed with the sealing layer 25.

[0028] <Method for manufacturing semiconductor device>

The method for manufacturing the semiconductor device 100 will be described. First, a structure 30 illustrated in FIG. 4(a) is prepared. That is, the first semiconductor element Wa is disposed in the recess 10a of the substrate 10. Thereafter, the first semiconductor element Wa and the circuit pattern C2 are electrically connected to each

other via the first wire 11.

[0029] Next, as illustrated in FIGS. 4(b) and 4(c), the film-like adhesive 15P of the laminate 20 separately prepared is pressed against the substrate 10. According to this, the first semiconductor element Wa and the first wire 11 are embedded in the film-like adhesive 15P. The thickness of the film-like adhesive 15P may be appropriately set depending on the thickness of the first semiconductor element Wa, the capacity of the recess 10a, and the like, and for example, may be in a range of 60 to 150 μm and may be 70 to 130 μm or 90 to 120 μm . When the thickness of the film-like adhesive 15P is set in the above-described range, an interval (distance G in FIG. 1) between the first semiconductor element Wa and the second semiconductor element Wb can be sufficiently secured. The distance G is, for example, 20 to 120 μm and may be 30 to 100 μm or 40 to 80 μm . The temperature when the film-like adhesive 15P is pressed against the substrate 10 is, for example, 80°C to 160°C.

[0030] The film-like adhesive 15P is preferably composed of a material that is a thermosetting resin composition, and for example, has a shear viscosity of 5000 Pa·s or less (preferably 200 to 4000 Pa·s) at any temperature of 60°C to 150°C (preferably 80°C to 140°C). From the viewpoint of embeddability, the shear viscosity at 80°C of the film-like adhesive 15P is preferably 500 Pa·s or more, more preferably 800 Pa·s or more, and even more preferably 1000 Pa·s or more.

[0031] Next, the film-like adhesive 15P is cured by heating. According to this, the first semiconductor element Wa is sealed with a cured product (first sealing layer 15) of the film-like adhesive 15P.

The curing treatment of the film-like adhesive 15P may be executed under a pressurized atmosphere from the viewpoint of reducing voids. After the second semiconductor element Wb and the circuit pattern C2 are electrically connected to each other via the second wire 12, the second semiconductor element Wb is sealed with the second sealing layer 25, and thereby the semiconductor device 100 is completed (see FIG. 1).

[0032] Incidentally, an example of the method for manufacturing the laminate 20 illustrated in FIG. 2 will be described herein with reference to FIGS. 5(a) to 5(e). First, a dicing die bonding integrated tape 8 (hereinafter, simply referred to as the "tape 8") is disposed in a predetermined apparatus (not illustrated). The tape 8 is provided with a base layer 1, a pressure-sensitive adhesive layer 2, and an adhesive layer 15A in this order. As illustrated in FIGS. 5(a) and 5(b), the tape 8 is pasted so that the adhesive layer 15A is in contact with one surface of a semiconductor wafer W. The base layer 1 is, for example, a polyethylene terephthalate film (PET film). The semiconductor wafer W is, for example, a thin semiconductor wafer having a thickness of 10 to 100 μm . The semiconductor wafer W may be single-crystal silicon and may be polycrystal silicon, various ceramics, or a compound semiconductor such as gallium arsenide.

[0033] As illustrated in FIG. 5(c), the semiconductor wafer W, the pressure-sensitive adhesive layer 2, and the adhesive layer 15A are diced. According to this, the semiconductor wafer W is individuated to become the semiconductor element Wb. The adhesive layer 15A is also individuated to become the film-like adhesive 15P. Incidentally,

the thickness may be decreased by grinding the semiconductor wafer W prior to the dicing of the semiconductor wafer W.

[0034] Next, in a case where the pressure-sensitive adhesive layer 2 is, for example, a UV curable type, as illustrated in FIG. 5(d), the pressure-sensitive adhesive layer 2 is cured by irradiating the pressure-sensitive adhesive layer 2 with ultraviolet rays, and thereby the pressure-sensitive adhesive force between the pressure-sensitive adhesive layer 2 and the film-like adhesive 15P is decreased. After irradiation of ultraviolet rays, as illustrated in FIG. 5(e), while the semiconductor elements Wb are separated from each other by expanding the base layer 1, the film-like adhesive 15P of the laminate 20 is peeled off from the pressure-sensitive adhesive layer 2 by being thrust up by a needle 42, and the laminate 20 is sucked by a suction collet 44 so as to be picked up. The laminate 20 obtained in this way is provided in the manufacturing of the semiconductor device 100 as illustrated in FIG. 4(b).

[0035] Hereinbefore, embodiments of the present disclosure have been specifically described, but the present invention is not limited to the above-described embodiments. For example, in the above-described embodiments, a case where the semiconductor device 100 is manufactured by using the substrate 10 having one recess 10a has been exemplified, but a substrate having a plurality of recesses may be used, and a semiconductor device in which semiconductor devices are disposed in the respective recesses may be manufactured. Furthermore, in the above-described embodiments, the package having an aspect of stacking two semiconductor elements Wa and Wb has been

exemplified, but the third semiconductor element may be stacked above the second semiconductor element Wb, and one or a plurality of semiconductor elements may be further stacked thereabove.

Examples

5 [0036] Hereinafter, the present disclosure will be described by means of Examples and Comparative Examples, but the scope of the present invention is not limited by these Examples.

[0037] [Examples 1a to 1c]

10 <Preparation of laminate including first semiconductor element and film-like adhesive>

A semiconductor wafer (silicon wafer, thickness: 775 μm) was prepared. This semiconductor wafer was ground by using a fully automatic grinder/polisher DGP-8761 (manufactured by DISCO Corporation) until the thickness became 30 μm . A dicing die bonding integrated film (manufactured by Hitachi Chemical Company, Ltd., thickness of the adhesive layer: 10 μm , thickness of the pressure-sensitive adhesive layer: 110 μm) was pasted to the semiconductor wafer. This pasting was performed by using a fully automatic multiple wafer mounter DFM-2800 (manufacture by DISCO Corporation) and the stage temperature was set to 70°C.

15 [0038] The above-described semiconductor wafer was diced under the following conditions. According to this, a first laminate including the first semiconductor element (controller chip) and the film-like adhesive was obtained.

25 · Use apparatus: 12-inch dual dicer DFD-6361 (manufactured by DISCO Corporation)

- Cutting method: Single cutting method
- Blade: ZH05-SD4800-N1-70-BB (manufactured by DISCO Corporation)

- Blade rotation number: 50000 rpm

5 · Cutting speed: 30 mm/sec

- Chip size: 3 mm × 3 mm

[0039] <Preparation of laminate including second semiconductor element and film-like adhesive>

10 A semiconductor wafer (silicon wafer, thickness: 775 μm) was prepared. A modifying layer was formed in the semiconductor wafer with laser by using a stealth laser dicer DFL-7361 (manufacture by DISCO Corporation) so that a semiconductor element having a size of 10 mm × 10 mm would be obtained. Subsequently, this semiconductor wafer was ground by using a fully automatic grinder/polisher

15 DGP-8761 (manufactured by DISCO Corporation) until the thickness became 60 μm. A dicing die bonding integrated film (manufactured by Hitachi Chemical Company, Ltd., thickness of the adhesive layer: 110 μm, thickness of the pressure-sensitive adhesive layer: 20 μm) was pasted to the semiconductor wafer. This pasting was performed by

20 using a fully automatic multiple wafer mounter DFM-2800 (manufacture by DISCO Corporation) and the stage temperature was set to 70°C. Incidentally, the adhesive layer of the above-described dicing die bonding integrated film is composed of a thermosetting resin composition having a relatively high elastic modulus at 260°C after

25 curing (about 90 to 120 MPa).

[0040] Subsequently, the semiconductor wafer and the adhesive layer

were individuated by expansion under the following conditions using a cooling expansion apparatus DDS2300 (manufactured by DISCO Corporation), and the obtained laminate (the second semiconductor and the film-like adhesive) was picked up.

- 5 · Temperature: -15°C
- Retention time in cooling chamber: 90 sec
- Quantity of thrust-up: 9 mm
- Speed of thrust-up: 300 mm/sec

10 Incidentally, regarding heat-shrink conditions, the quantity of thrust-up was set to 7 mm, the speed of thrust-up was set to 30 mm/sec, the retention time was set to 15 sec, and the dryer temperature was set to 220°C. After washing and drying were executed, UV was applied to the pressure-sensitive adhesive layer. Regarding UV conditions, the illumination intensity was set to 100 mW/cm² and the irradiance level
15 was set to 150 mJ/cm². According to this, a second laminate including the second semiconductor wafer and the film-like adhesive was obtained.

[0041] <Die bonding of first semiconductor element>

20 Three types of substrates each having a recess on the surface (manufactured by Hitachi Chemical Company, Ltd., E-700G) were prepared. As for the three types of substrates, the sizes of the recesses were different from each other, the sizes of the recesses were 5 mm × 5 mm, 7.1 mm × 7.1 mm, and 8.7 mm × 8.7 mm, respectively, and the depth was 10 μm in all recesses. The first laminate was
25 pressure-bonded to the center of the recess of each substrate under the following conditions.

· Apparatus: Die bonder DB-830plus+ (manufactured by FASFORD TECHNOLOGY CO., LTD.)

· Pressure-bonding condition: Temperature 120°C, time for 1 sec, pressure 1.0 MPa

5 [0042] The film-like adhesive of the first laminate was cured under the following conditions.

· Apparatus: Fully automatic pressure oven PCOA-01T (manufactured by NTT Advanced Technology Corporation)

10 · Curing condition: After holding at a temperature of 90°C and a pressure of 0.3 MPa for 3 minutes, holding at 140°C and 0.7 MPa for 35 minutes

[0043] <Die bonding of second semiconductor element>

15 The second laminate was pressure-bonded onto the substrate under the following conditions after die bonding the first semiconductor element.

· Position: The positioning of the second laminate was performed so that the center of the first semiconductor element coincided with the center of the second semiconductor element.

20 · Pressure-bonding condition: Temperature 120°C, time for 1.5 sec, pressure 1.5 MPa

[0044] Three types of structures (Examples 1a to 1c) which were structures obtained after pressure-bonding the second semiconductor element and in which the sizes of the recesses were different from each other were used as evaluation targets described below. Hereinafter, 25 Examples 1a to 1c are collectively referred to as Example 1 in some cases.

[0045] [Comparative Example 1]

Structures for evaluation (Comparative Examples 1a to 1c) were obtained in the same manner as in Example 1, except that the first semiconductor element was pressure-bonded to a surface of a substrate having no recess on the surface.

[0046] [Example 2]

Structures for evaluation were obtained in the same manner as in Example 1, except that the thickness of the first semiconductor element was set to 40 μm instead of 30 μm . Three types of structures (Examples 2a to 2c) which were structures obtained after pressure-bonding the second semiconductor element and in which the sizes of the recesses were different from each other were used as evaluation targets described below. Hereinafter, Examples 2a to 2c are collectively referred to as Example 2 in some cases.

[Comparative Example 2]

Structures for evaluation (Comparative Examples 2a to 2c) were obtained in the same manner as in Example 2, except that the first semiconductor element was pressure-bonded to a surface of a substrate having no recess on the surface.

[0047] [Example 3]

Structures for evaluation were obtained in the same manner as in Example 1, except that the thickness of the first semiconductor element was set to 50 μm instead of 30 μm . Three types of structures (Examples 3a to 3c) which were structures obtained after pressure-bonding the second semiconductor element and in which the sizes of the recesses were different from each other were used as

evaluation targets described below. Hereinafter, Examples 3a to 3c are collectively referred to as Example 3 in some cases.

[0048] [Comparative Example 3]

5 Structures for evaluation (Comparative Examples 3a to 3c) were obtained in the same manner as in Example 3, except that the first semiconductor element was pressure-bonded to a surface of a substrate having no recess on the surface.

[0049] <Evaluation of bowing>

10 The structures of Examples 1 to 3 and Comparative Examples 1 to 3 are made by assuming a chip-embedded type semiconductor device. The bowing amount of these structures was measured as follows. That is, Digimatic Indicator ID-H0530 (manufactured by Mitutoyo Corporation) was used, five points of upper right, upper right, center, lower left, and lower right of the structure placed on the plane were
15 regarded as measurement points, and a value obtained by subtracting the minimum value from the maximum value of the measurement result was regarded as the bowing amount. The improvement rate of the bowing amount by using the substrate having a recess was calculated by the following equations.

20 · Improvement rate (%) of Example 1 = (Bowing amount of Comparative Example 1 - Bowing amount of Example 1)/Bowing amount of Comparative Example 1 × 100

· Improvement rate (%) of Example 2 = (Bowing amount of Comparative Example 2 - Bowing amount of Example 2)/Bowing
25 amount of Comparative Example 2 × 100

· Improvement rate (%) of Example 3 = (Bowing amount of

Comparative Example 3 - Bowing amount of Example 3)/Bowing amount of Comparative Example 3 $\times 100$

[0050] The evaluation results of the bowing amount are shown in Tables 1 to 3. As shown in Tables 1 to 3, except Example 1-1 (the size of the recess was 5 mm $\times$ 5 mm), the improvement rate of the bowing amount was a positive value. Incidentally, the structure of Example 1-1 has a negative value of the improvement rate of the bowing amount, but a difference in bowing amount between Example 1-1 and Comparative Example is 0.7 μm ($= 26 \mu\text{m} - 25.3 \mu\text{m}$), and thus this structure can be evaluated to be at a practically available level.

[0051] <Evaluation of embeddability>

The embeddability of the first semiconductor element in the structures of Examples 1 to 3 and Comparative Examples 1 to 3 was evaluated as follows.

· Apparatus: Ultrasonic digital image diagnosis apparatus IS-350 (manufactured by Insight k.k)

· Measurement: Transmission (probe: 35 MHz, scanning length (X: 100 mm, Y: 50 mm), pitch: 0.1 mm)

[0052] In order to quantitatively evaluate the embeddability of the first semiconductor element by the film-like adhesive, the obtained image was edited using an image editing software (Photoshop (registered trademark) manufactured by Adobe) and the void ratio was calculated. That is, a part embedded by the film-like adhesive was displayed as white, a part (void) not embedded was displayed as black, and the ratio of the void (void ratio) was calculated. The improvement rate of the void ratio by using the substrate having a recess was calculated by the

following equations.

· Improvement rate (%) of Example 1 = (Void ratio of Comparative Example 1 - Void ratio of Example 1)/Void ratio of Comparative Example 1 $\times$ 100

5 · Improvement rate (%) of Example 2 = (Void ratio of Comparative Example 2 - Void ratio of Example 2)/Void ratio of Comparative Example 2 $\times$ 100

10 · Improvement rate (%) of Example 3 = (Void ratio of Comparative Example 3 - Void ratio of Example 3)/Void ratio of Comparative Example 3 $\times$ 100

[0053] The evaluation results of the void ratio are shown in Tables 1 to 3. As shown in Tables 1 to 3, except a case where the size of the recess is 5 mm $\times$ 5 mm (Example 1-1, Example 2-1, and Example 3-1), the improvement rate of the void ratio was a positive value.

15 Incidentally, in a case where the size of the recess is 5 mm $\times$ 5 mm, since the gap between the side surface of the recess and the first semiconductor element (size: 3 mm $\times$ 3 mm) was only 1 mm, it is speculated that the adhesive was less likely to penetrate into this gap and the void ratio was high.

[0054] [Table 1]

		Example 1a	Example 1b	Example 1c	Comparative Example 1
First semiconductor element	Size	3 mm × 3 mm			
	Thickness	30 μm			
	Thickness of film-like adhesive	10 μm			
Thickness of first laminate		40 μm			
Second semiconductor element	Size	10 mm × 10 mm			
	Thickness	60 μm			
	Thickness of film-like adhesive	110 μm			
Recess	Presence/absence	Present			Absent
	Depth	10 μm			
	Size	5 mm × 5 mm	7.1 mm × 7.1 mm	8.7 mm × 8.7 mm	
Gap between first semiconductor element and side surface of recess		1.0 mm	2.1 mm	2.9 mm	-
Ratio of depth of recess to thickness of first laminate		25.0%	25.0%	25.0%	-
Ratio of area of recess to area of second semiconductor element		25.0%	50.4%	75.7%	-
Evaluation of bowing	Bowing amount	26.0 μm	14.7 μm	19.2 μm	25.3 μm
	Improvement rate of bowing amount	-2.6%	42.1%	24.3%	-
Evaluation of embeddability	Void ratio	15.9%	1.6%	4.2%	7.4%
	Improvement rate of void ratio	-116.6%	77.7%	43.1%	-

[0055] [Table 2]

		Example 2a	Example 2b	Example 2c	Comparative Example 2
First semiconductor element	Size	3 mm × 3 mm			
	Thickness	40 μm			
	Thickness of film-like adhesive	10 μm			
Thickness of first laminate		50 μm			
Second semiconductor element	Size	10 mm × 10 mm			
	Thickness	60 μm			
	Thickness of film-like adhesive	110 μm			
Recess	Presence/absence	Present			Absent
	Depth	10 μm			
	Size	5 mm × 5 mm	7.1 mm × 7.1 mm	8.7 mm × 8.7 mm	
Gap between first semiconductor element and side surface of recess		1.0 mm	2.1 mm	2.9 mm	-
Ratio of depth of recess to thickness of first laminate		20.0%	20.0%	20.0%	-
Ratio of area of recess to area of second semiconductor element		25.0%	50.4%	75.7%	-
Evaluation of bowing	Bowing amount	30.0 μm	21.3 μm	26.8 μm	33.0 μm
	Improvement rate of bowing amount	9.1%	35.4%	18.7%	-
Evaluation of embeddability	Void ratio	17.2%	2.1%	4.4%	9.2%
	Improvement rate of void ratio	-87.8%	77.6%	52.2%	-

[0056] [Table 3]

		Example 3a	Example 3b	Example 3c	Comparative Example 3
First semiconductor element	Size	3 mm × 3 mm			
	Thickness	50 μm			
	Thickness of film-like adhesive	10 μm			
Thickness of first laminate		60 μm			
Second semiconductor element	Size	10 mm × 10 mm			
	Thickness	60 μm			
	Thickness of film-like adhesive	110 μm			
Recess	Presence/absence	Present			Absent
	Depth	10 μm			-
	Size	5 mm × 5 mm	7.1 mm × 7.1 mm	8.7 mm × 8.7 mm	-
Gap between first semiconductor element and side surface of recess		1.0 mm	2.1 mm	2.9 mm	-
Ratio of depth of recess to thickness of first laminate		16.7%	16.7%	16.7%	-
Ratio of area of recess to area of second semiconductor element		25.0%	50.4%	75.7%	-
Evaluation of bowing	Bowing amount	32.7 μm	23.7 μm	30.3 μm	35.8 μm
	Improvement rate of bowing amount	8.8%	34.0%	15.3%	-
Evaluation of embeddability	Void ratio	15.0%	2.1%	4.1%	5.1%
	Improvement rate of void ratio	-194.0%	59.6%	18.8%	-

Industrial Applicability

[0057] According to the present disclosure, there are provided a semiconductor device having a useful configuration for achieving an improvement in embeddability of a film-like adhesive composed of a thermosetting resin composition and reducing the entire bowing and a manufacturing method therefor.

Reference Signs List

[0058] 10: substrate, 10a: recess, 11: first wire, 12: second wire, 15: first sealing layer (cured product of film-like adhesive), 15P: film-like adhesive, 20: laminate, 100: semiconductor device, C1, C2: circuit pattern, Wa: first semiconductor element, Wb: second semiconductor element.

CLAIMS

1. A method for manufacturing a semiconductor device, the method comprising:

a step of preparing a substrate having a recess;

5 a step of disposing a first semiconductor element in the recess of the substrate;

a step of preparing a laminate of a film-like adhesive composed of a thermosetting resin composition and a second semiconductor element by dicing;

10 a step of pressing the laminate against the substrate so that the film-like adhesive covers a region including the recess in the substrate and the first semiconductor element is embedded in the film-like adhesive; and

15 a step of sealing the first semiconductor element with a cured product of the film-like adhesive by heating the film-like adhesive, wherein

an area of the recess is smaller than an area of the second semiconductor element.

2. The method for manufacturing a semiconductor device according to claim 1, wherein the area of the recess is 30 to 80% with respect to the area of the second semiconductor element.

3. The method for manufacturing a semiconductor device according to claim 1 or 2, wherein a depth of the recess is 10 to 30% with respect to a height of the first semiconductor element.

25 4. The method for manufacturing a semiconductor device according to any one of claims 1 to 3, wherein a thickness of the

film-like adhesive is 60 to 150 μm .

5. The method for manufacturing a semiconductor device according to any one of claims 1 to 4, wherein in a state where the first semiconductor element is disposed in the recess, a gap between the first semiconductor element and a side surface of the recess is 1.2 to 5 mm.

6. The method for manufacturing a semiconductor device according to any one of claims 1 to 5, wherein a shear viscosity at any temperature of 60°C to 150°C of the film-like adhesive is 5000 Pa·s or less.

7. The method for manufacturing a semiconductor device according to any one of claims 1 to 6, wherein the substrate has a circuit pattern on a surface, and

the method further includes a first wire bonding step of electrically connecting the first semiconductor element and the circuit pattern to each other.

8. The method for manufacturing a semiconductor device according to claim 7, further comprising:

a second wire bonding step of electrically connecting the second semiconductor element and the circuit pattern to each other; and

a step of sealing the second semiconductor element and the second wire with a resin composition.

9. The method for manufacturing a semiconductor device according to any one of claims 1 to 8, further comprising a step of stacking a third semiconductor element above the second semiconductor element.

10. The method for manufacturing a semiconductor device

according to any one of claims 1 to 9, wherein the first semiconductor element is sealed with a cured product of the film-like adhesive by heating the film-like adhesive under a pressurized atmosphere.

11. A semiconductor device comprising:

- 5 a substrate having a recess;
 a first semiconductor element disposed in the recess;
 a first sealing layer disposed to cover a region including the recess in the substrate and sealing the first semiconductor element; and
 a second semiconductor element disposed to cover a surface in
10 the first sealing layer opposite to the side of the substrate, wherein
 the first sealing layer is composed of a cured product of a film-like adhesive composed of a thermosetting resin composition, and
 an area of the recess is smaller than an area of the second semiconductor element.

15 12. The semiconductor device according to claim 11, wherein the area of the recess is 30 to 80% with respect to the area of the second semiconductor element.

20 13. The semiconductor device according to claim 11 or 12, wherein a depth of the recess is 10 to 30% with respect to a height of the first semiconductor element.

14. The semiconductor device according to any one of claims 11 to 13, wherein a gap between the first semiconductor element and a side surface of the recess is 1.2 to 5 mm.

25 15. The semiconductor device according to any one of claims 11 to 14, wherein a thickness of the substrate is 90 to 140 μm .

16. The semiconductor device according to any one of claims 11 to

15, further comprising:

a circuit pattern formed on a surface of the substrate; and

a first wire electrically connecting the first semiconductor element and the circuit pattern to each other.

5 17. The semiconductor device according to claim 16, further comprising:

a second wire electrically connecting the second semiconductor element and the circuit pattern to each other; and

10 a second sealing layer sealing the second semiconductor element and the second wire.

18. The semiconductor device according to any one of claims 11 to 17, further comprising a third semiconductor element stacked above the second semiconductor element.