

## DESCRIPTION

FILM-LIKE ADHESIVE, SEMICONDUCTOR PACKAGE USING FILM-LIKE  
ADHESIVE, AND METHOD FOR PRODUCING THE SAME

## TECHNICAL FIELD

[0001] The present invention relates to a film-like adhesive, a semiconductor package using the film-like adhesive, and a method for producing the semiconductor package.

## BACKGROUND ART

[0002] In recent years, stacked MCP's (Multi Chip Packages) having chips stacked in multiple levels have been widely popularized, and stacked MCP's are mounted as memory packages for mobile telephones and portable audio equipment. Furthermore, along with the diverse functionalization of mobile telephones and the like, density increase and enhanced integration of packages have also been promoted. Accordingly, further attempts in multilevel stacking of chips are in progress.

[0003] For the adhesion between a wiring board and a semiconductor chip and between semiconductor chips during the course of production for such a memory package, paste-like or film-like adhesives (die attach films) have been used, and die attach films that do not easily bring about the contamination of other members such as semiconductor chips and wire pads

caused by resin flow, resin crawling up or the like, are usually used.

[0004] In regard to the mounting of semiconductor chips using die attach films, since the surfaces of wiring boards and semiconductor chips are not necessarily in a smooth surface state, air may be trapped into the interface between the die attach film and the adherend during a die attach process. The entrapped air (voids) not only causes deterioration of the adhesive power after heating and curing, but also causes package cracking. In order to prevent entrapment of voids, there is an increasing demand for a thermosetting type die attach film that is used by lowering the viscosity of the die attach film at the time of mounting, making the die attach film to conform to the face of surface unevenness thoroughly, and then curing the film.

[0005] In regard to the multilevel stacking of semiconductor chips in a package using a thermosetting type die attach film, it is necessary to shorten the curing time in order to achieve shortening of the production process. When the curing temperature is raised, the curing rate of the thermosetting resin contained in the thermosetting type die attach film is also increased, and the curing time can be shortened. However, voids that are causative of package cracking or the like are prone to occur inside the die attach film during the curing process. Regarding these problematic

voids, there is no practical problem when the die attach film is cured while fine voids having a maximum width of less than about 300  $\mu\text{m}$  (see Fig. 8(A)), which have entered at the time of die attachment, remain at that size; however, it is expected that if the die attach film is cured at a high temperature, those problematic voids occur as a result of the fine voids expanding to a maximum width of about 500  $\mu\text{m}$  or more (see Fig. 8(B)) during curing. It is speculated that the ease of expansion of voids in this case is attributable to: (i) low melt viscosity properties of the die attach film at the time of curing, and (ii) slow curability of the die attach film.

[0006] As a conventional thermosetting type die attach film, an adhesive film has been disclosed, which has a minimum melt viscosity of 2,000 Pa·s or less and has the minimum melt viscosity within a temperature range of 50°C to 170°C (see Patent Document 1). Since this adhesive film has the viscosity characteristics as described above, the adhesiveness at low temperatures, and the properties of the adhesive film conforming to fine concavities and convexities at the surface of a substrate or the like can be enhanced. However, proper attention is not paid to the curing rate of the die attach film, and there is a problem that since no improvement has been made for the slow curability, voids that are causative of package cracking or the like during curing are prone to occur.

[0007] Furthermore, there has also been disclosed an

adhesive film which contains an epoxy resin, a curing agent, and fumed silica particles, and has a minimum melt viscosity in the range of 2,500 Pa·s to 10,000 Pa·s in a temperature range of 70°C to 120°C (see Patent Document 2). However, attention is not paid to the melt viscosity in a temperature region exceeding 120°C, which is required for the curing of die attach films, and there is a problem that since the content of fumed silica is small, a decrease in the melt viscosity is brought about in a temperature region exceeding 120°C, and voids that are causative of package cracking or the like during curing are prone to occur.

#### CITATION LIST

##### PATENT DOCUMENT

[0008] Patent Document 1: JP 2007-103954 A

Patent Document 2: JP 2010-28087 A

#### SUMMARY OF THE INVENTION

##### PROBLEM TO BE SOLVED BY THE INVENTION

[0009] Thus, it is an object of the present invention to provide a film-like adhesive which can reduce the occurrence of voids even in a case in which curing is performed at a high temperature in a short period of time during multilevel stacking of semiconductor chips, a semiconductor package using the film-like adhesive, and a method for producing the

semiconductor package.

#### MEANS FOR SOLVING PROBLEM

[0010] In order to solve the problems described above, the film-like adhesive according to the present invention includes an epoxy resin (A), an epoxy resin curing agent (B), a phenoxy resin (C), and a silica filler (D), in which the content of the silica filler (D) is 30% to 70% by mass relative to the total amount of the epoxy resin (A), the epoxy resin curing agent (B), the phenoxy resin (C) and the silica filler (D), when the temperature is increased from room temperature at a rate of temperature increase of 5°C/min, the film-like adhesive exhibits a minimum melt viscosity in the range of 200 Pa·s to 10,000 Pa·s in a temperature range of higher than 120°C and 180°C or lower, and the gelation time at 180°C according to the hot plate method defined in JIS K6911 is 1 second to 200 seconds.

[0011] It is preferable that the film-like adhesive adds hydrophobic fumed silica having a specific surface area of 10 m<sup>2</sup>/g to 300 m<sup>2</sup>/g according to the BET method defined in JIS Z8830, as at least one kind of the silica filler (D).

[0012] Furthermore, in order to solve the problems described above, the method for producing a semiconductor package according to the present invention includes a first step of providing an adhesive layer and a dicing tape on the back surface of a wafer having at least one semiconductor circuit

formed on the front surface, by thermally compressing the film-like adhesive and a dicing tape on the back surface of the wafer; a second step of simultaneously dicing the wafer and the adhesive layer, and thereby obtaining an adhesive layer-attached semiconductor chip that includes the wafer and the adhesive layer; a third step of detaching the dicing tape from the adhesive layer, and thermally compressing the adhesive layer-attached semiconductor chip and a wiring board, with the adhesive layer being interposed therebetween; and a fourth step of thermally curing the adhesive layer.

[0013] Furthermore, in order to solve the problems described above, the semiconductor package according to the present invention is obtained by the method for producing a semiconductor package described above.

#### EFFECT OF THE INVENTION

[0014] The film-like adhesive, the semiconductor package using the film-like adhesive, and a method for producing the semiconductor package according to the present invention can reduce the occurrence of voids even in a case in which curing is performed at a high temperature for a short period of time during multilevel stacking of semiconductor chips. Thereby, the semiconductor package using the film-like adhesive according to the present invention does not deteriorate the adhesive power to the substrate of a semiconductor chip or to

another semiconductor chip, and can reduce the occurrence of package cracking. Furthermore, the method for producing a semiconductor package using the film-like adhesive according to the present invention can produce a semiconductor package in a short period of time.

#### BRIEF DESCRIPTION OF DRAWINGS

[0015] Fig. 1 is an explanatory diagram explaining a first step of the method for producing a semiconductor package related to an embodiment of the present invention;

Fig. 2 is an explanatory diagram explaining a second step of the method for producing a semiconductor package related to the embodiment of the present invention;

Fig. 3 is an explanatory diagram explaining a third step of the method for producing a semiconductor package related to the embodiment of the present invention;

Fig. 4 is an explanatory diagram explaining a fifth step of the method for producing a semiconductor package related to the embodiment of the present invention;

Fig. 5 is a cross-sectional diagram schematically illustrating the structure of a semiconductor chip mounted using the film-like adhesive related to an embodiment of the present invention;

Fig. 6 is a cross-sectional diagram schematically illustrating the structure of another semiconductor chip

mounted using the film-like adhesive related to the embodiment of the present invention;

Fig. 7 is a cross-sectional diagram schematically illustrating the structure of the semiconductor package related to an embodiment of the present invention; and

Fig. 8(A) is a plan view diagram schematically illustrating the conformation of a conventional die attach film-attached glass chip after thermally compressing the glass chip to a wiring board, and Fig. 8(B) is a plan view diagram schematically illustrating the conformation of a conventional die attach film-attached glass chip after thermally compressing the glass chip to a wiring board and then heating and curing the die attach film.

#### MODE(S) FOR CARRYING OUT THE INVENTION

[0016] Hereinafter, embodiments of the present invention will be described in detail.

[0017] The film-like adhesive related to an embodiment of the present invention includes an epoxy resin (A), an epoxy resin curing agent (B), a phenoxy resin (C), and a silica filler (D), in which the content of the silica filler (D) is 30% to 70% by mass relative to the total amount of the epoxy resin (A), the epoxy resin curing agent (B), the phenoxy resin (C) and the silica filler (D), when the temperature is increased from room temperature at a rate of temperature increase of 5°C/min, the

film-like adhesive exhibits a minimum melt viscosity in the range of 200 Pa·s to 10,000 Pa·s in a temperature range of higher than 120°C and 180°C or lower, and the gelation time at 180°C according to the hot plate method defined in JIS K6911 is 1 second to 200 seconds.

[0018]        The film-like adhesive related to the embodiment of the present invention is such that when the temperature is increased from room temperature at a rate of temperature increase of 5°C/min, the minimum melt viscosity is in the range of 200 Pa·s to 10,000 Pa·s in a temperature range of higher than 120°C and 180°C or lower. The minimum melt viscosity is more preferably in the range of 200 Pa·s to 3,000 Pa·s, and particularly preferably in the range of 200 Pa·s to 2,000 Pa·s. If the minimum melt viscosity is larger than 10,000 Pa·s, when a semiconductor chip provided with the present film-like adhesive is thermally compressed on a wiring board, gaps are likely to remain between the concavities and convexities of the wiring board. Furthermore, if the minimum melt viscosity is smaller than 200 Pa·s, when a semiconductor chip provided with the present film-like adhesive is mounted on a wiring board and then thermally cured, voids are prone to occur.

[0019]        Meanwhile, according to the embodiment of the present invention, the melt viscosity is the viscous resistance obtainable at a temperature of higher than 120°C and 180°C or lower from a temperature-viscous resistance curve obtained by

measuring the change in the viscous resistance using a rheometer in a temperature range of 30°C to 200°C at a rate of temperature increase of 5°C/min. Furthermore, for the melt viscosity obtained under these conditions, the temperature at which the minimum melt viscosity is reached (minimum melt viscosity-reaching temperature), is correlated to the curing rate of the film-like adhesive material, and when the minimum melt viscosity is on the side of a lower temperature, this means that the curing rate is faster.

[0020] Furthermore, the film-like adhesive related to the embodiment of the present invention is such that the gelation time at 180°C according to the hot plate method defined in JIS K6911 is in the range of 50 seconds to 200 seconds. Furthermore, the 180°C gelation time is preferably in the range of 100 seconds to 200 seconds, and in particular, more preferably in the range of 150 seconds to 200 seconds. If the 180°C gelation time is longer than 200 seconds, the curing time is lengthened, and voids are prone to occur upon thermal curing. If the 180°C gelation time is shorter than 50 seconds, the film-like adhesive is likely to undergo thermal curing at a lower temperature, and there is a possibility that thermal curing may proceed at the time of a heat treatment for drying the solvent at the time of film production.

[0021] Meanwhile, according to the embodiment of the present invention, the gelation time is measured according to

JIS 6911 using a gelation testing machine at a stage temperature of 180°C.

[0022] (Epoxy resin (A))

The epoxy resin (A) included in the adhesive film related to the present invention is not particularly limited as long as the epoxy resin has epoxy groups.

[0023] For the skeleton of the epoxy resin (A), resins of phenol-novolac type, ortho-cresol-novolac type, dicyclopentadiene type, biphenyl type, fluorene-bisphenol A type, triazine type, naphthol type, naphthalenediol type, triphenylmethane type, tetraphenyl type, bisphenol A type, bisphenol F type, bisphenol AD type, bisphenol S type, trimethylolmethane type, and the like can be used.

[0024] In regard to the epoxy resin (A), in order to increase the crosslinking density of a cured product and to consequently increase the mechanical strength and heat resistance, the epoxy equivalent is preferably 500 g/eq or less, and more preferably 150 g/eq to 450 g/eq. Meanwhile, according to the present invention, the epoxy equivalent means the number of grams of a resin containing 1 gram equivalent of epoxy groups (g/eq).

[0025] The epoxy resin (A) may be used singly, or two or more kinds thereof may be used in combination. In a case in which two or more kinds are used in combination, for example, from the viewpoint that regulation of the viscosity of the

composition is made easier, and even in the case of carrying out a process of thermally compressing a film-like adhesive and a wafer (wafer lamination process) at a low temperature (preferably, 40°C to 80°C), sufficient adhesiveness between the wafer and the film-like adhesive tends to be exhibited, it is preferable to use an epoxy resin (a1) having a softening point of 50°C to 100°C and an epoxy resin (a2) having a softening point below 50°C in combination.

[0026] The epoxy resin (a1) is solid or semi-solid at room temperature, and the softening point is preferably 50°C to 100°C, and more preferably 50°C to 80°C. If the softening point is below 50°C, the viscosity of the adhesive thus obtainable decreases, and therefore, there is a tendency that it is difficult to maintain the film shape at normal temperature. On the other hand, if the softening point is above 100°C, there is a tendency that it is difficult for the film-like adhesive thus obtainable to reach a minimum melt viscosity in the range of 200 Pa·s to 10,000 Pa·s in a temperature range of higher than 120°C and 180°C or lower.

[0027] Regarding the epoxy resin (a1), the weight average molecular weight is preferably more than 500 and 2,000 or less, and more preferably from 600 to 1,200. If the weight average molecular weight is 500 or less, the amount of monomers or dimers is increase, and thereby higher crystallinity is exhibited. Therefore, the film-like adhesive tends to become fragile. On

the other hand, if the weight average molecular weight is more than 2,000, since the melt viscosity of the film-like adhesive increases, embedding of the concavities and convexities on the substrate cannot be sufficiently achieved when the film-like adhesive is compressed to a wiring board, and the adhesiveness between the film-like adhesive and the wiring board tends to decrease.

[0028] Regarding the skeleton of such an epoxy resin (a1), from the viewpoint that the crystallinity of the resin is low, and a film-like adhesive having satisfactory external appearance is obtained, resins of triphenylmethane type, bisphenol A type, cresol-novolac type, ortho-cresol-novolac type, and dicyclopentadiene type are preferred, and a triphenylmethane type epoxy resin, a bisphenol A type epoxy resin, and a cresol-novolac type epoxy resin are more preferred.

[0029] Regarding the epoxy resin (a2), an epoxy resin having a softening point below 50°C is preferred, and an epoxy resin having a softening point of 40°C or lower is more preferred, so that even in the case of carrying out a process of thermally compressing the film-like adhesive and a wafer (wafer lamination process) at a low temperature (preferably, 40°C to 80°C), sufficient adhesiveness between the wafer and the film-like adhesive is exhibited. Regarding such an epoxy resin (a2), the weight average molecular weight is preferably 300 to 500, and more preferably 350 to 450. If the weight average

molecular weight is less than 300, the amount of monomers is increased, and thereby higher crystallinity is exhibited. Therefore, the film-like adhesive tends to become fragile. On the other hand, if the weight average molecular weight is more than 500, since the melt viscosity increases, the adhesiveness between the wafer and the film-like adhesive tends to be decreased during the wafer lamination process.

[0030] Regarding the skeleton of such an epoxy resin (a2), from the viewpoint that the crystallinity of the resin is low, and a film-like adhesive having satisfactory external appearance is obtained, resins of bisphenol A type, bisphenol A/F mixed type, bisphenol F type, and propylene oxide-modified bisphenol A type, which are oligomer type liquid epoxy resins, are preferred. Also, from the viewpoint of having low melt viscosity and lower crystallinity, a bisphenol A type epoxy resin and a bisphenol A/F mixed type epoxy resin are more preferred.

[0031] The proportions of the epoxy resin (a1) and the epoxy resin (a2) are preferably such that the mass ratio (a1 : a2) is 95 : 5 to 30 : 70, and more preferably 70 : 30 to 40 : 60. If the content of the epoxy resin (a1) is less than the lower limit described above, the film tackiness of the film-like adhesive becomes stronger, and it tends to become difficult to detach the film-like adhesive from a cover film or a dicing tape. On the other hand, if the content is more than the upper limit

described above, the viscosity of the composition increases, and the nature of the film-like adhesive thus obtainable tends to become brittle.

[0032] (Epoxy resin curing agent (B))

Regarding the epoxy resin curing agent (B) used for the present invention, known curing agents such as amines, acid anhydrides, and polyvalent phenols can be used; however, the epoxy resin curing agent (B) is preferably a latent curing agent which exhibits curability at a predetermined temperature equal to or higher than normal temperature, for example, at or above a temperature at which the epoxy resin (A) exhibits necessary tacky adhesiveness, and which exhibits rapid curability.

Regarding the latent curing agent, dicyandiamide, imidazoles, hydrazides, a boron trifluoride-amine complex, amineimide, a polyamine salt and modification products thereof, and microcapsule type curing agents can also be used. These can be used singly or as mixtures of two or more kinds thereof. When a latent curing agent is used, a composition for a film-like adhesive having high storage stability, which is capable of even long-term storage at room temperature, can be provided. The amount of use of the epoxy resin curing agent (B) is usually in the range of 0.5% to 50% by mass with respect to the epoxy resin (A). In order to adjust the gelation time at 180°C according to the hot plate method defined in JIS K6911 to 1 second to 200 seconds, it is preferable to use a certain amount by parts

of a curing agent having a high curing rate, such as an imidazole. Furthermore, it is preferable to use an imidazole as a catalyst in the case of using dicyandiamide as the curing agent.

[0033] (Phenoxy resin (C))

The phenoxy resin (C) used for the present invention is used in order to impart sufficient adhesiveness and film-making properties (film forming properties) to the film-like adhesive. Since phenoxy resins have a structure similar to that of epoxy resins, phenoxy resins have satisfactory compatibility, and also have low resin melt viscosities and satisfactory adhesiveness. A phenoxy resin is a thermoplastic resin usually having a molecular weight of 10,000 or more, which is obtainable from a bisphenol such as bisphenol A and epichlorohydrin. When a phenoxy resin is incorporated, an effect is obtained in solving problems such as tackiness at room temperature and brittleness. Regarding preferred phenoxy resins, commercially available phenoxy resins such as 1256 (bisphenol A type phenoxy resin, manufactured by Mitsubishi Chemical Corp.), YP-70 (bisphenol A/F type phenoxy resin, manufactured by Shin Nikka Epoxy Seizo K.K.), FX-316 (bisphenol F type phenoxy resin, manufactured by Shin Nikka Epoxy Seizo K.K.), and FX-280S (cardo-skeleton type phenoxy resin, manufactured by Shin Nikka Epoxy Seizo K.K.) may also be used as the phenoxy resin (C).

[0034] (Silica filler (D))

The silica filler (D) used for the present invention contributes to reduced absorption of the film-like adhesive and a decrease in the coefficient of linear expansion. If the value of the coefficient of linear expansion is high, the difference in the coefficient of linear expansion between the film-like adhesive and an adherend such as a wiring board becomes larger. Therefore, the interface between the film-like adhesive and the adherend is subjected to stress, and this leads to the occurrence of package cracking, which is not preferable.

[0035] The content of the silica filler (D) is 30% to 70% by mass, and more preferably 40% to 60% by mass, relative to the total amount of the epoxy resin (A), the epoxy resin curing agent (B), the phenoxy resin (C), and the silica filler (D). This is because the minimum melt viscosity value is controlled by the amount of incorporation of the silica filler. If the amount of incorporation is larger than 70% by mass, the minimum melt viscosity value becomes large, and when a semiconductor chip provided with the present film-like adhesive is thermally compressed on a wiring board, gaps are likely to remain between the concavities and convexities of the wiring board. Also, film fragility is increased. If the amount of incorporation is smaller than 30% by mass, the minimum melt viscosity value becomes small, and voids are prone to occur at the time of curing.

[0036] From the viewpoints of enhanced filling and fluidity, it is desirable that the silica filler (D) is

spherical in shape. Furthermore, the average particle size is preferably 0.01  $\mu\text{m}$  to 5  $\mu\text{m}$ . If the particle size is smaller than 0.01  $\mu\text{m}$ , the filler particles may easily aggregate, and at the time of film production, unevenness occurs, so that the uniformity of the film thickness of the adhesive film thus obtained may be deteriorated. If the particle size is larger than 5  $\mu\text{m}$ , when a thin film is produced with a coating machine such as a roll knife coater, the filler particles serve as starting points, and streaks are easily generated on the film surface.

[0037] Meanwhile, according to the present invention, the average particle size refers to the particle size obtainable 50% accumulation when the total volume of the particles in the particle size distribution is designated as 100%, and the average particle size can be determined from a cumulative curve of volume fractions of the particle size of a particle size distribution analyzed by a laser diffraction scattering method (analysis conditions: dispersing medium: sodium hexametaphosphate, laser wavelength: 780 nm, analytic apparatus; MICROTRAC MT3300EX). Furthermore, according to the present invention, being spherical means that the shape is true spherical, or approximately true spherical that is round substantially without angular corners.

[0038] Regarding the method for incorporating the silica filler (D) into a resin binder, a method of directly

incorporating a powdered spherical silica filler and optionally a silane coupling agent (integrant method), or a method of incorporating a slurry-like silica filler obtained by dispersing spherical silica filler particles that have been surface-treated with a silane coupling agent in an organic solvent, can be used. Particularly, in a case in which a thin film is produced, it is more preferable to use a slurry-like silica filler. This is because when an epoxy resin, an epoxy resin curing agent, and resin components such as a polymer are mixed into a surface-treated spherical silica filler dispersion liquid dispersed in a smaller organic solvent, even spherical silica filler particles having a small particle size can be uniformly dispersed without aggregating in the resin components, and the surface external appearance of the film-like adhesive thus obtainable becomes satisfactory. Regarding the silane coupling agent to be used, agents containing amino groups and epoxy groups are preferred.

[0039] The silica filler (D) may be used singly, or two or more kinds thereof may be used in combination. In a case in which two or more kinds are used in combination, it is preferable to use a hydrophobic fumed silica having a specific surface area of  $10 \text{ m}^2/\text{g}$  to  $300 \text{ m}^2/\text{g}$  according to the BET method defined in JIS Z8830, as at least one. When hydrophobic fumed silica is added, the minimum melt viscosity can be readily adjusted to a high level. If the specific surface area is

smaller than  $10 \text{ m}^2/\text{g}$ , the hydrophobic fumed silica particles may easily aggregate, and at the time of film production, unevenness occurs, so that the uniformity of the film thickness of the adhesive film thus obtained may be deteriorated. If the specific surface area is larger than  $300 \text{ m}^2/\text{g}$ , the melt viscosity increasing effect is not easily exhibited.

[0040] Furthermore, the amount of filling in the case of using hydrophobic fumed silica in combination is not particularly limited; however, the amount of filling is preferably 0.1% to 10% by mass relative to the total amount of the (A) epoxy resin and the (C) phenoxy resin, and more preferably 1% to 5% by mass relative to the total amount of the (A) epoxy resin and the (C) phenoxy resin. If the amount of incorporation is larger than 10% by mass, hydrophobic fumed silica particles easily aggregate, and at the time of film production, unevenness occurs, so that the uniformity of the film thickness of the adhesive film thus obtained may be deteriorated. The amount of incorporation is smaller than 0.1% by mass, the melt viscosity increasing effect is not easily exhibited, and voids are prone to occur at the time of curing.

[0041] Examples of the hydrophobic fumed silica include AEROSIL RY200 (specific surface area:  $100 \text{ m}^2/\text{g}$ , manufactured by Nippon Aerosil Co., Ltd.), AEROSIL RY200S (specific surface area:  $80 \text{ m}^2/\text{g}$ , manufactured by Nippon Aerosil Co., Ltd.), AEROSIL RY50 (specific surface area:  $30 \text{ m}^2/\text{g}$ , manufactured by

Nippon Aerosil Co., Ltd.), AEROSIL NY50 (specific surface area: 30 m<sup>2</sup>/g, manufactured by Nippon Aerosil Co., Ltd.), AEROSIL RY300 (specific surface area: 125 m<sup>2</sup>/g, manufactured by Nippon Aerosil Co., Ltd.), and AEROSIL R202 (specific surface area: 100 m<sup>2</sup>/g, manufactured by Nippon Aerosil Co., Ltd.).

[0042]        The composition for a film-like adhesive of the present invention may further include, in addition to the epoxy resin (A), the epoxy resin curing agent (B), the polymer component (C) and the silica filler (D), additives such as a viscosity adjusting agent, an oxidation inhibitor, a flame retardant, a colorant, and a stress relaxing agent such as a butadiene-based rubber or a silicone rubber within a range of not impairing the effect of the present invention.

[0043]        As a suitable embodiment of the method for producing a film-like adhesive of the present invention, a method of applying a composition for a film-like adhesive on one surface of a release-treated substrate film, and subjecting the composition to heating and drying, may be use; however, the production method is not intended to be particularly limited to this method. The release-treated substrate film may be any substrate film which functions as a cover film of the film-like adhesive thus obtainable, and any known substrate film can be appropriately employed. Examples thereof include a release-treated polypropylene (PP), a release-treated polyethylene (PE), and a release-treated polyethylene

terephthalate (PET). Regarding the coating method, any known method can be appropriately employed, and for example, methods using a roll knife coater, a gravure coater, a die coater, a reverse coater, and the like may be mentioned.

[0044] Regarding the film-like adhesive of the present invention obtained as such, the thickness is preferably 5  $\mu\text{m}$  to 200  $\mu\text{m}$ , and from the viewpoint that the concavities and convexities at the surface of a wiring board or a semiconductor chip can be more sufficiently embedded, the thickness is more preferably 5  $\mu\text{m}$  to 40  $\mu\text{m}$ . If the thickness is less than 5  $\mu\text{m}$ , the concavities and convexities at the surface of a wiring board or a semiconductor chip are not sufficiently embedded, and there is a tendency that sufficient adhesiveness cannot be secured. On the other hand, if the thickness is more than 200  $\mu\text{m}$ , since it becomes difficult to remove the organic solvent at the time of production, the amount of residual solvent increases, and the film tackiness tends to become stronger.

[0045] Furthermore, the minimum melt viscosity of the present invention can be achieved by a combination of the composition and the mixing ratio such as described above, and also can be achieved by partially performing a curing reaction of the epoxy resin by intentionally performing a preliminary heat treatment after film production, and increasing the melt viscosity. Thus, the occurrence of voids at the time of high temperature thermal curing in a semiconductor assembling

process can be suppressed. The preliminary heat treatment temperature used at this time is preferably 80°C to 150°C, and more preferably 100°C to 130°C. The preliminary heat treatment time is preferably 5 minutes to 300 minutes, and more preferably 30 minutes to 200 minutes.

[0046] Subsequently, a suitable embodiment of the method for producing a semiconductor package of the present invention will be explained in detail with reference to the drawings. Meanwhile, identical symbols will be assigned to identical or equivalent elements in the following descriptions and drawings, and any overlapping descriptions will not be repeated. Fig. 1 to Fig. 7 are outline vertical cross-sectional diagrams illustrating suitable embodiments of the various steps of the method for producing a semiconductor package of the present invention.

[0047] In regard to the method for producing a semiconductor package of the present invention, first, as illustrated in Fig. 1 as a first step, the film-like adhesive of the present invention is thermally compressed onto the back surface of a wafer 1 having at least one semiconductor circuit formed on the front surface, and thereby an adhesive layer 2 is provided. Subsequently, a dicing tape 3 is bonded with the wafer 1 by means of the adhesive layer 2. At this time, it is also acceptable to thermally compress a manufactured product in which the adhesive layer 2 and the dicing tape 3 have been

integrated in advance, all at once. The dicing tape 3 is not particularly limited, and any known dicing tape can be used. Regarding the wafer 1, a wafer having at least one semiconductor circuit formed on the surface can be appropriately used, and examples include a silicon wafer, a SiC wafer, and a GaAs wafer. Regarding the adhesive layer 2, the film-like adhesive of the present invention may be used singly as one layer, or may also be used as a laminate of two or more layers. Regarding the method of providing such an adhesive layer 2 on the back surface of the wafer 1, a method capable of laminating the film-like adhesive on the back surface of the wafer 1 can be appropriately employed. Examples include a method of bonding the film-like adhesive to the back surface of the wafer 1, and then, in the case of laminating two or more layers, laminating the film-like adhesive in sequence until a desired thickness is obtained; and a method of laminating the film-like adhesive in advance to a desired thickness, and then bonding the laminate to the back surface of the wafer 1. Furthermore, the apparatus used when these adhesive layers 2 are provided on the back surface of the wafer 1 is not particularly limited, and for example, known apparatuses such as a roll laminator and a manual laminator can be appropriately used.

[0048] Next, in regard to the method for producing a semiconductor package of the present invention, as illustrated in Fig. 2 as a second step, an adhesive layer-attached

semiconductor chip 5 including a semiconductor chip 4 and the adhesive layer 2 is obtained by simultaneously dicing the wafer 1 and the adhesive layer 2. The apparatus used for the dicing is also not particularly limited, and any known dicing apparatus can be appropriately used.

[0049] Next, in regard to the method for producing a semiconductor package of the present invention, as illustrated in Fig. 3 as a third step, the dicing tape 3 is detached from the adhesive layer 2, the adhesive layer-attached semiconductor chip 5 and a wiring board 6 are thermally compressed, with the adhesive layer 2 interposed therebetween, and thereby the semiconductor chip 4 is mounted on the wiring board 6.

Regarding the wiring board 6, a board having a semiconductor circuit formed on the front surface can be appropriately used, and examples thereof include a printed circuit board (PCB), various lead frames, and boards having electronic components such as a resistance element and a condenser mounted on the board surface.

[0050] The method for mounting the semiconductor chip 4 as such is not particularly limited, and a conventional method capable of adhering an adhesive layer-attached semiconductor chip 5 to a wiring board 6 or to an electronic component mounted on the surface of a wiring board 6 by utilizing the adhesive layer 2, can be appropriately employed. Regarding such a mounting method, conventionally known heating and pressurizing

methods such as a method of using a mounting technology using a flip-chip bonder which has a function of heating from above; a method of using a die bonder which has a function of heating only from below, and a method of using a laminator, may be used. As such, when a semiconductor chip 4 is mounted on a wiring board 6 by means of an adhesive layer 2 formed from the film-like adhesive of the present invention, the adhesive layer 2 (film-like adhesive) can be made to conform to the concavities and convexities on the wiring board 6 produced by electronic components. Therefore, the wafer 1 and the wiring board 6 can be fixed by close adhesion.

[0051] Subsequently, in regard to the method for producing a semiconductor package of the present invention, as a fourth step, the adhesive layer 2 is thermally cured. The thermosetting temperature is not particularly limited as long as the temperature is higher than or equal to the thermosetting initiation temperature of the film-like adhesive (adhesive layer 2), and since the thermosetting temperature varies depending on the kind of the resin used, the temperature cannot be fixed to a general value. However, the thermosetting temperature is preferably higher than 120°C and 180°C or lower, and from the viewpoint that curing at a higher temperature enables curing in a shorter period of time, the thermosetting temperature is more preferably 140°C to 180°C. If the temperature is lower than the thermosetting initiation

temperature, thermal curing does not proceed sufficiently, and the strength of the adhesive layer 2 tends to decrease. On the other hand, if the thermosetting temperature is higher than 180°C, the epoxy resin, the curing agent, or the additives in the film-like adhesive tend to volatilize easily and foam during the course of curing. Furthermore, the time for the curing treatment is preferably, for example, 10 minutes to 120 minutes. According to the present invention, since the film-like adhesive can be cured in a short period of time by thermally curing the film-like adhesive at a high temperature, a semiconductor package in which the wiring board 6 and the wafer 1 are strongly adhered can be obtained, without having voids generated even if the semiconductor package is cured at a high temperature.

[0052] Next, in regard to the method for producing a semiconductor package of the present invention, as illustrated in Fig. 4 as a fifth step, it is preferable to connect the wiring board 6 and the semiconductor chip 4 by means of a bonding wire 7. Such a connection method is not particularly limited, and any conventionally known method, for example, a wire bonding method or a TAB (Tape Automated Bonding) method, can be appropriately employed.

[0053] Furthermore, plural semiconductor chips can be laminated by thermally compressing and thermally curing another adhesive layer-attached semiconductor chip 5 on the surface of

the mounted semiconductor chip 4, and connecting the semiconductor chip 5 to the wiring board 7 by the wire bonding method again. For example, as illustrated in Fig. 5, a method of stacking the semiconductor chip 4 by cascading, or as illustrated in Fig. 6, a method of stacking the semiconductor chip 4 while embedding the bonding wire 7 by making the adhesive layer 2 starting from the second layer thicker, may be used.

[0054] In regard to the method for producing a semiconductor package of the present invention, as illustrated in Fig. 7, it is preferable that the wiring board 6 and the semiconductor chip 4 are sealed by means of a sealing resin 8, and thus the semiconductor package 9 of the present invention can be obtained. The sealing resin 8 is not particularly limited, and any known sealing resin that can be used for the production of semiconductor packages can be appropriately used. Furthermore, the sealing method using the sealing resin 8 is not particularly limited, and any known method can be appropriately employed.

[0055] According to such a method for producing a semiconductor package of the present invention, even if high temperature curing is performed, the wafer 1 can be fixed to the wiring board 6 without having voids generated in the adhesive layer 2 formed from a film-like adhesive. Particularly, in a case in which semiconductor chips 4 are stacked in multiple levels as in the case of a memory package,

curing in a short period of time can be achieved by high temperature curing, and therefore, shortening of the package assembling time is enabled.

[0056] Hereinafter, the present invention will be explained more specifically based on Examples and Comparative Examples, but the present invention is not intended to be limited to the following Examples.

[0057] (Example 1)

First, 310 parts by mass of a slurry-like surface-treated spherical silica filler (trade name: SC2050-KNP, silica average particle size: 0.5  $\mu\text{m}$ , surface treating agent:

3-glycidoxypropyltrimethoxysilane, solvent: MIBK, solid content concentration: 70 wt%, manufactured by Admatechs Co., Ltd.), 56 parts by mass of a solid cresol-novolac type epoxy resin (trade name: EOCN-1020-70, softening point: 70°C, solid, epoxy equivalent: 200, manufactured by Nippon Kayaku Co., Ltd.), 49 parts by mass of a liquid bisphenol A type epoxy resin (trade name: YD-128, softening point: 25°C or lower, liquid, epoxy equivalent: 190, manufactured by Shin Nikka Epoxy Seizo K.K.), and 30 parts by mass of a bisphenol A type phenoxy resin (trade name: YP-50S, Tg: 84°C, manufactured by Shin Nikka Epoxy Seizo K.K.) were weighed and mixed, and the mixture was heated and stirred for 2 hours at a temperature of 110°C in a 500-ml separable flask. Thus, a resin mixture was obtained.

Subsequently, 445 parts by mass of this resin mixture was

transferred into an 800-ml planetary mixer, and 9 parts by mass of an imidazole type curing agent (trade name: 2PHZ-PW, manufactured by Shikoku Chemicals Corp.) and 2 parts by mass of hydrophobic fumed silica (trade name: RY-200, specific surface area: 100 m<sup>2</sup>/g, manufactured by Nippon Aerosil Co., Ltd.) were added thereto, and the mixture was stirred and mixed for 1 hour at room temperature, and then was defoamed in a vacuum. Subsequently, a composition for a film-like adhesive was obtained. Subsequently, the composition for a film-liked adhesive thus obtained was applied on a release-treated PET film having a thickness of 38 μm, and the PET film was heated and dried for 10 minutes at a temperature of 100°C. Thus, a film-like adhesive having a size of 200 mm × 300 mm and a thickness of 20 μm was obtained.

[0058] (Example 2)

A composition for a film-like adhesive and a film-like adhesive were obtained in the same manner as in Example 1, except that a dicyclopentadiene type epoxy resin (trade name: XD-1000, softening point: 70°C, solid, epoxy equivalent: 250, manufactured by Nippon Kayaku Co., Ltd.) was used instead of the cresol-novolac type epoxy resin.

[0059] (Example 3)

First, 286 parts by mass of a slurry-like surface-treated spherical silica filler (trade name: SC2050-KNP, silica average particle size: 0.5 μm, surface treating agent:

3-glycidoxypropyltrimethoxysilane, solvent: MIBK, solid content concentration: 70 wt%, manufactured by Admatechs Co., Ltd.), 40 parts by mass of a solid bisphenol A type epoxy resin (trade name: JER1002, softening point: 78°C, solid, epoxy equivalent: 200, manufactured by Mitsubishi Chemical Corp.), 100 parts by mass of a liquid bisphenol A type epoxy resin (trade name: YD-128, softening point: 25°C or lower, liquid, epoxy equivalent: 190, manufactured by Shin Nikka Epoxy Seizo K.K.), and 100 parts by mass of a bisphenol A type phenoxy resin (trade name: YP-50S, Tg: 84°C, manufactured by Shin Nikka Epoxy Seizo K.K.) were weighed and mixed, and the mixture was heated and stirred for 2 hours at a temperature of 110°C in a 500-ml separable flask. Thus, a resin mixture was obtained. Next, 440 parts by mass of this resin mixture was transferred into an 800-ml planetary mixer, and 6 parts of a dicyandiamide type curing agent (trade name: DICY7, manufactured by Mitsubishi Chemical Corp.), 1 part by mass of an imidazole type curing agent (trade name: 2PHZ-PW, manufactured by Shikoku Chemicals Corp.) and 7 parts by mass of hydrophobic fumed silica (trade name: RY-200, specific surface area: 100 m<sup>2</sup>/g, manufactured by Nippon Aerosil Co., Ltd.) were added thereto. The mixture was stirred and mixed for 1 hour at room temperature, and then was defoamed in a vacuum. Thus, a composition for a film-like adhesive was obtained. Subsequently, the composition for a film-like adhesive thus obtained was applied on a release-treated PET film

having a thickness of 38  $\mu\text{m}$ , and the PET film was heated and dried for 10 minutes at a temperature of 100°C. Thus, a film-like adhesive having a size of 200 mm  $\times$  300 mm and a thickness of 20  $\mu\text{m}$  was obtained.

[0060] (Example 4)

A composition for a film-like adhesive and a film-like adhesive were obtained in the same manner as in Example 3, except that 7 parts by mass of hydrophobic fumed silica (trade name: RY-200S, specific surface area: 80 m<sup>2</sup>/g, manufactured by Nippon Aerosil Co., Ltd.) was used.

[0061] (Example 5)

A composition for a film-like adhesive and a film-like adhesive were obtained in the same manner as in Example 4, except that 2 parts by mass of hydrophobic fumed silica (trade name: RY-200S, specific surface area: 80 m<sup>2</sup>/g, manufactured by Nippon Aerosil Co., Ltd.) was used.

[0062] (Example 6)

First, 286 parts by mass of a slurry-like surface-treated spherical silica filler (trade name: SC2050-KNP, silica average particle size: 0.5  $\mu\text{m}$ , surface treating agent: 3-glycidoxypropyltrimethoxysilane, solvent: MIBK, solid content concentration: 70 wt%, manufactured by Admatechs Co., Ltd.), 40 parts by mass of a solid bisphenol A type epoxy resin (trade name: JER1002, softening point: 78°C, solid, epoxy equivalent: 200, manufactured by Mitsubishi Chemical Corp.),

100 parts by mass of a liquid bisphenol A type epoxy resin (trade name: YD-128, softening point: 25°C or lower, liquid, epoxy equivalent: 190, manufactured by Shin Nikka Epoxy Seizo K.K.), and 100 parts by mass of a bisphenol A type phenoxy resin (trade name: YP-50S, Tg: 84°C, manufactured by Shin Nikka Epoxy Seizo K.K.) were weighed and mixed, and the mixture was heated and stirred for 2 hours at a temperature of 110°C in a 500-ml separable flask. Thus, a resin mixture was obtained. Next, 440 parts by mass of this resin mixture was transferred into an 800-ml planetary mixer, and 6 parts of a dicyandiamide type curing agent (trade name: DICY7, manufactured by Mitsubishi Chemical Corp.) and 1 part by mass of an imidazole type curing agent (trade name: 2PHZ-PW, manufactured by Shikoku Chemicals Corp.) were added thereto. The mixture was stirred and mixed for 1 hour at room temperature, and then was defoamed in a vacuum. Thus, a composition for a film-like adhesive was obtained. Subsequently, the composition for a film-like adhesive thus obtained was applied on a release-treated PET film having a thickness of 38  $\mu\text{m}$ , and the PET film was heated and dried for 10 minutes at a temperature of 100°C. Thus, a film-like adhesive having a size of 200 mm  $\times$  300 mm and a thickness of 20  $\mu\text{m}$  was obtained. This film was further heated for 3 hours at a temperature of 120°C, and thereby the film was intentionally subjected to partial thermal curing. Thus, a film having an increased melt viscosity was produced.

[0063] (Comparative Example 1)

First, 154 parts by mass of a slurry-like surface-treated spherical silica filler (trade name: SC2050-KNP, silica average particle size: 0.5  $\mu\text{m}$ , surface treating agent:

3-glycidoxypropyltrimethoxysilane, solvent: MIBK, solid content concentration: 70 wt%, manufactured by Admatechs Co., Ltd.), 49 parts by mass of a liquid bisphenol A type epoxy resin (trade name: YD-128, softening point: 25°C or lower, liquid, epoxy equivalent: 190, manufactured by Shin Nikka Epoxy Seizo K.K.), and 30 parts by mass of a bisphenol A type phenoxy resin (trade name: YP-50S, Tg: 84°C, manufactured by Shin Nikka Epoxy Seizo K.K.) were weighed and mixed, and the mixture was heated and stirred for 2 hours at a temperature of 110°C in a 500-ml separable flask. Thus, a resin mixture was obtained. Next, 233 parts by mass of this resin mixture was transferred into an 800-ml planetary mixer, and 0.8 parts by mass of a triphenylphosphine type curing catalyst (trade name: TPP-K, manufactured by Hokko Chemical Industry Co., Ltd.) was added thereto. The mixture was stirred and mixed for 1 hour at room temperature, and then was defoamed in a vacuum. Thus, a composition for a film-like adhesive was obtained.

Subsequently, the composition for a film-like adhesive thus obtained was applied on a release-treated PET film having a thickness of 38  $\mu\text{m}$ , and the PET film was heated and dried for 10 minutes at a temperature of 100°C. Thus, a film-like

adhesive having a size of 200 mm × 300 mm and a thickness of 20 μm was obtained.

[0064] (Comparative Example 2)

A composition for a film-like adhesive and a film-like adhesive were obtained in the same manner as in Example 6, except that the intentional thermal curing process for 3 hours at 120°C was not carried out.

[0065] (Comparative Example 3)

A composition for a film-like adhesive and a film-like adhesive were obtained in the same manner as in Comparative Example 2, except that a chain-like alicyclic epoxy epoxy resin (trade name: EP-4000L, softening point: 25°C lower, liquid, epoxy equivalent: 255, manufactured by Adeka Corp.) was used instead of the liquid bisphenol A type epoxy resin.

[0066] (Comparative Example 4)

First, 56 parts by mass of a solid cresol-novolac type epoxy resin (trade name: EOCN-1020-70, softening point: 70°C, solid, epoxy equivalent: 200, manufactured by Nippon Kayaku Co., Ltd.), 49 parts by mass of a liquid bisphenol A type epoxy resin (trade name: YD-128, softening point: 25°C or lower, liquid, epoxy equivalent: 190, manufactured by Shin Nikka Epoxy Seizo K.K.), 30 parts by mass of a bisphenol A type phenoxy resin (trade name: YP-50S, Tg: 84°C, manufactured by Shin Nikka Epoxy Seizo Co., Ltd.), and 93 parts by mass of MIBK were weighed and mixed, and the mixture was heated and stirred for 2 hours at a

temperature of 110°C in a 500-ml separable flask. Thus, a resin mixture was obtained. Next, 445 parts by mass of this resin mixture was transferred into an 800-ml planetary mixer, and 9 parts by mass of an imidazole type curing agent (trade name: 2PHZ-PW, manufactured by Shikoku Chemicals Corp.) and 2 parts by mass of hydrophobic fumed silica (trade name: RY-200, specific surface area: 100 m<sup>2</sup>/g, manufactured by Nippon Aerosil Co. Ltd.) were added thereto. The mixture was stirred and mixed for 1 hour at room temperature, and then was defoamed in a vacuum. Thus, a composition for a film-like adhesive was obtained. Subsequently, the composition for a film-like adhesive thus obtained was applied on a release-treated PET film having a thickness of 38 μm, and the film was heated and dried for 10 minutes at a temperature of 100°C. Thus, a film-like adhesive having a size of 200 mm × 300 mm and a thickness of 20 μm was obtained.

[0067] (Comparative Example 5)

A composition for a film-like adhesive and a film-like adhesive were obtained in the same manner as in Example 1, except that 617 parts by mass of a slurry-like surface-treated spherical silica filler was used.

[0068] The minimum melt viscosity, gelation time, evaluation of voids after curing, and film properties of the film-like adhesives related to the Examples and Comparative Examples were subjected to the following evaluations. The

results are presented in Tables 1 and 2.

[0069] (Measurement of minimum melt viscosity)

Each of the film-like adhesives related to the Examples and Comparative Examples was cut out into a size of 5.0 cm × 5.0 cm, and the film-like adhesive pieces were laminated using a hand roller on a hot plate at a stage temperature of 70°C, and thus a specimen having a thickness of about 1.0 mm was obtained. For this specimen, the change in the viscous resistance over a temperature range of 20°C to 250°C at a rate of temperature increase of 5°C/min was measured using a rheometer (RS6000, manufactured by Haake Technik GmbH), and from a temperature-viscous resistance curve thus obtained, the minimum melt viscosity (Pa·s) and the minimum melt viscosity-reaching temperature (°C) were calculated.

[0070] (Measurement of gelation time)

Each of the film-like adhesives related to the Examples and Comparative Examples was cut out into a size that weighed about 2 g, and the gelation time at a stage temperature of 180°C was measured according to JIS K6911 using a gelation testing machine (trade name: A0E1, manufactured by Imoto Machinery Co., Ltd.).

[0071] (Evaluation of voids after thermal curing)

Each of the film-like adhesives related to the Examples and Comparative Examples was first adhered to one surface of a dummy silicon wafer (aluminum-deposited silicon wafer, 8-inch

size, thickness 100  $\mu\text{m}$ ) at a temperature of 70°C and a pressure of 0.3 MPa using a manual laminator (trade name: FM-114, manufactured by TechnoVision, Inc.), and then using the same manual laminator, a dicing tape (trade name: K-13, manufactured by Furukawa Electric Co., Ltd.) and a dicing frame (trade name: DTF2-8-1H001, manufactured by Disco Corp.) were adhered to the surface of the film-like adhesive opposite to the dummy silicon wafer, at room temperature and a pressure of 0.3 MPa.

Subsequently, the assembly was subjected to dicing into a size of 10 mm  $\times$  10 mm using a dicing apparatus (trade name: DFD-6340, manufactured by Disco Corp.) equipped with a biaxial dicing blade (Z1: NBC-ZH2050 (27 HEDD), manufactured by Disco Corp. / Z2: NBC-ZH127F-SE (BC), manufactured by Disco Corp.). Thus, semiconductor chips were obtained.

Subsequently, the semiconductor chips were thermally compressed on a glass substrate (10 cm  $\times$  10 cm in size, thickness 700  $\mu\text{m}$ ) using a die bonder (trade name: DB-800, manufactured by Hitachi High Technologies Corp.) under the conditions of a temperature of 120°C, a pressure of 0.1 MPa (load 1,000 gf), and a time of 1.0 second. The initial state in the film-like adhesive after thermal compression was observed through the back surface of the glass substrate. Thereafter, this was disposed in a dryer and was heated at a temperature of 180°C for 10 minutes to thereby thermally cure the film-like adhesive. The state in the film-like adhesive after thermal curing was

observed through the back surface of the glass substrate. After thermal compression and after thermal curing, the film-like adhesive was evaluated by checking whether voids were recognized by visual inspection, and a film-like adhesive in which even if voids were recognized, the number of voids having a maximum width of less than 300  $\mu\text{m}$  was less than 10, and the voids were substantially not expanding and were developing into voids that caused package cracking, was rated as "O", which meant a superior product. On the other hand, after thermal compression, the film-like adhesive was evaluated by checking whether voids were recognized by visual inspection, and a film-like adhesive in which even if voids were recognized, the number of voids having a maximum width of less than 300  $\mu\text{m}$  was less than 10, but after thermal curing, the voids expanded and developed into voids that caused package cracking, with the number of voids having a maximum width of 500  $\mu\text{m}$  or more being 10 or more, was evaluated as "X" as a defective product.

| Composition                                                                                |                                    | Example 1     | Example 2     | Example 3     | Example 4     | Example 5     | Example 6 |
|--------------------------------------------------------------------------------------------|------------------------------------|---------------|---------------|---------------|---------------|---------------|-----------|
| Epoxy resin<br>(parts by mass)                                                             | Cresol-novolac type (solid)        | 56            | -             | -             | -             | -             | -         |
|                                                                                            | Bisphenol A type (solid)           | -             | -             | 40            | 40            | 40            | 40        |
|                                                                                            | Dicyclopentadiene type (solid)     | -             | 56            | -             | -             | -             | -         |
|                                                                                            | Bisphenol A type (liquid)          | 49            | 49            | 100           | 100           | 100           | 100       |
|                                                                                            | Chain-like/alicyclic (liquid)      | -             | -             | -             | -             | -             | -         |
| Phenoxy resin<br>(parts by mass)                                                           | Bisphenol A type                   | 30            | 30            | 100           | 100           | 100           | 100       |
| Epoxy resin curing<br>agent (parts by mass)                                                | Dicyandiamide type curing<br>agent | -             | -             | 6             | 6             | 6             | 6         |
|                                                                                            | Imidazole type curing agent        | 9             | 9             | 1             | 1             | 1             | 1         |
|                                                                                            | Phenol type curing agent           | -             | -             | -             | -             | -             | -         |
| Slurry-like surface-treated spherical silica filler<br>(solid content 70%) (parts by mass) |                                    | 310           | 310           | 286           | 286           | 286           | 286       |
| Hydrophobic fumed<br>silica (parts by mass)                                                | RY-200                             | 2             | 2             | 7             | -             | -             | -         |
|                                                                                            | RY-200S                            | -             | -             | -             | 7             | 2             | -         |
| Heat treatment (120 degrees/3 hours)                                                       |                                    | Not Performed | Not Performed | Not Performed | Not Performed | Not Performed | Performed |
| Silica filler content (mass%)                                                              |                                    | 59.8          | 59.8          | 44.1          | 44.1          | 44.6          | 44.7      |
| Amount of hydrophobic fumed silica filling (mass%)                                         |                                    | 1.5           | 1.5           | 1.5           | 1.5           | 0.4           | 0         |
| Film properties                                                                            |                                    | ○             | ○             | ○             | ○             | ○             | ○         |
| Minimum melt viscosity-reaching temperature (°C)                                           |                                    | 125           | 135           | 160           | 162           | 158           | 146       |
| Minimum melt viscosity (Pa·s)                                                              |                                    | 2000          | 2100          | 400           | 328           | 230           | 1500      |
| Gelation time @ 180°C (sec)                                                                |                                    | 165           | 185           | 193           | 194           | 191           | 180       |
| Evaluation of voids after thermal curing                                                   |                                    | ○             | ○             | ○             | ○             | ○             | ○         |

| Composition                                                                                |                                    | Comparative<br>Example 1 | Comparative<br>Example 2 | Comparative<br>Example 3 | Comparative<br>Example 4 | Comparative<br>Example 5 |
|--------------------------------------------------------------------------------------------|------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Epoxy resin<br>(parts by mass)                                                             | Cresol-novolac type (solid)        | -                        | -                        | -                        | 56                       | 56                       |
|                                                                                            | Bisphenol A type (solid)           | -                        | 40                       | 40                       | -                        | -                        |
|                                                                                            | Dicyclopentadiene type<br>(solid)  | -                        | -                        | -                        | -                        | -                        |
|                                                                                            | Bisphenol A type (liquid)          | 49                       | 100                      | -                        | 49                       | 49                       |
| Phenoxy resin<br>(parts by mass)                                                           | Chain-like/alicyclic (liquid)      | -                        | -                        | 100                      | -                        | -                        |
|                                                                                            | Bisphenol A type                   | 30                       | 100                      | 100                      | 30                       | 30                       |
| Epoxy resin curing<br>agent (parts by mass)                                                | Dicyandiamide type curing<br>agent | -                        | 6                        | 6                        | -                        | -                        |
|                                                                                            | Imidazole type curing agent        | -                        | 1                        | 1                        | 9                        | 9                        |
|                                                                                            | Phenol type curing agent           | 29                       | -                        | -                        | -                        | -                        |
| Slurry-like surface-treated spherical silica filler<br>(solid content 70%) (parts by mass) |                                    | 154                      | 286                      | 286                      | -                        | 617                      |
| Hydrophobic fumed<br>silica (parts by mass)                                                | RY-200                             | -                        | -                        | -                        | -                        | -                        |
|                                                                                            | RY-200S                            | -                        | -                        | -                        | -                        | -                        |
| Heat treatment (120 degrees/3 hours)                                                       |                                    | Not Performed            | Not Performed            | Not Performed            | Not Performed            | Not Performed            |
| Silica filler content (mass%)                                                              |                                    | 49.9                     | 44.7                     | 44.7                     | 0                        | 75                       |
| Amount of hydrophobic fumed silica filling (mass%)                                         |                                    | 0                        | 0                        | 0                        | 0                        | 0                        |
| Film properties                                                                            |                                    | ○                        | ○                        | ○                        | ○                        | ×                        |
| Minimum melt viscosity-reaching temperature (°C)                                           |                                    | 142                      | 155                      | 160                      | 115                      | 130                      |
| Minimum melt viscosity (Pa·s)                                                              |                                    | 1187                     | 107                      | 100                      | 30                       | 11000                    |
| Gelation time @ 180°C (sec)                                                                |                                    | 265                      | 190                      | 513                      | 140                      | 180                      |
| Evaluation of voids after thermal curing                                                   |                                    | ×                        | ×                        | ×                        | ×                        | ○                        |

[0074] As indicated in Table 1, in Examples 1 to 6, the content of the silica filler (D) was 44.1% to 59.8% by mass relative to the total amount of the epoxy resin (A), the epoxy resin curing agent (B), the phenoxy resin (C) and the silica filler (D), which fell in the range of 30% to 70% by mass as defined in Claim 1. When the film-like adhesives were heated from room temperature at a rate of temperature increase of 5°C/min, the film-like adhesives exhibited minimum melt viscosities in the range of 230 Pa·s to 2,100 Pa·s in a temperature range of higher than 120°C and 180°C or lower, which fell in the range of 200 Pa·s to 10,000 Pa·s as defined in Claim 1. The gelation time at 180°C according to the hot plate method defined in JIS K6911 was 165 seconds to 195 seconds, which fell in the range of 1 second to 200 seconds as defined in Claim 1, and therefore, the film-like adhesives exhibited excellent film properties. Furthermore, despite that the film-like adhesives were cured at a high temperature in a short period of time, such as 180°C and 10 minutes, the film-like adhesives could be cured satisfactorily without any expansion of voids.

[0075] On the other hand, as indicated in Table 2, in Comparative Example 1, since the gelation time was 265 seconds, which was longer than 200 seconds, voids were expanded. In Comparative Example 2, since the minimum melt viscosity was 107 Pa·s, which was lower than 200 Pa·s, expansion of voids occurred as well. In Comparative Example 3, since a silica filler was not included, and the minimum melt viscosity was 30 Pa·s, which was lower than 200 Pa·s, expansion of voids also occurred. In

Comparative Example 4, since the content of the silica filler was 75% by mass, which was higher than 70% by mass, and the minimum melt viscosity was higher than 10,000 Pa·s, inferior film properties were obtained.

#### EXPLANATIONS OF LETTERS OR NUMERALS

- [0076]            1: WAFER
- 2: ADHESIVE LAYER
- 3: DICING TAPE
- 4: SEMICONDUCTOR CHIP
- 5: ADHESIVE LAYER-ATTACHED SEMICONDUCTOR CHIP
- 6: WIRING BOARD
- 7: BONDING WIRE
- 8: SEALING RESIN
- 9: SEMICONDUCTOR PACKAGE

## CLAIMS

1. A film-like adhesive for die attachment comprising an epoxy resin (A), an epoxy resin curing agent (B), a phenoxy resin (C), and a silica filler (D),

wherein the content of the silica filler (D) is 30% to 70% by mass relative to the total amount of the epoxy resin (A), the epoxy resin curing agent (B), the phenoxy resin (C) and the silica filler (D),

when the film-like adhesive is heated from room temperature at a rate of temperature increase of 5°C/min, the film-like adhesive exhibits a minimum melt viscosity in the range of 200 Pa·s to 10,000 Pa·s in a temperature range of higher than 120°C and 180°C or lower, and

the gelation time at 180°C according to the hot plate method defined in JIS K6911 is 165 second to 200 seconds.

2. The film-like adhesive according to claim 1, wherein the film-like adhesive comprises a hydrophobic fumed silica having a specific surface area according to the BET method defined in JIS Z8830 of 10 m<sup>2</sup>/g to 300 m<sup>2</sup>/g, as at least one of the silica filler (D).

3. A method for producing a semiconductor package, the method comprising:

a first step of thermally compressing the film-like adhesive according to claim 1 or 2 and a dicing tape on the back surface of a wafer having at least one semiconductor circuit

formed on the front surface, and thereby providing an adhesive layer and a dicing tape on the back surface of the wafer;

a second step of simultaneously dicing the wafer and the adhesive layer, and thereby obtaining an adhesive layer-attached semiconductor chip including the wafer and the adhesive layer;

a third step of detaching the dicing tape from the adhesive layer, and thermally compressing the adhesive layer-attached semiconductor chip and a wiring board, with the adhesive layer interposed therebetween; and

a fourth step of thermally curing the adhesive layer.