

TITLE OF THE INVENTION

SEALABLE RESIN SHEET

TECHNICAL FIELD

[0001]

The present invention relates to a sealable resin sheet.

BACKGROUND ART

[0002]

It has been known to form a cured product from a sealing body by press sealing a semiconductor element or electronic component mounted on a board with a sealable sheet containing thermosetting resin, and thereafter curing the thermosetting resin in the sealing body by heating (for example, see Patent document 1 below).

Citation List

Patent Document

[0003]

Patent Document 1: Japanese Unexamined Patent Publication No. 2016-162909

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0004]

As electronic devices have been getting more sophisticated in functionality, there is a need to downsize the semiconductor elements or electronic components included therein. With the need, there is another need to increase the dimensional accuracy at the curing of the resin (cured product) that protects the semiconductor elements or electronic components. Specifically, there is a need to reduce an entering amount of the cured product that enters between the semiconductor element or electronic component and the board from a lateral edge of the semiconductor element or electronic component. An excellent sealability to seal an element is also required.

[0005]

The present invention provides a sealable resin sheet that can reduce an entering amount of a cured product that enters between an element exemplified by a semiconductor element or an

electronic component and the board, or a sealable resin sheet with an excellent sealability to seal an element.

MEANS FOR SOLVING THE PROBLEM

[0006]

The present invention [1] includes a sealable resin sheet for sealing an element, the sealable resin sheet containing thermosetting resin, wherein a ratio ($\eta^*_{\text{MIN at 80 to 120}^\circ\text{C}}/\eta^*_{\text{at 50}^\circ\text{C}}$) of a lowest complex viscosity $\eta^*_{\text{MIN at 80 to 120}^\circ\text{C}}$ at 80°C to 120°C to a complex viscosity $\eta^*_{\text{at 50}^\circ\text{C}}$ at 50°C is 0.170 or more when the complex viscosity η^* of the sealable resin sheet is evaluated in a dynamic viscoelastic measurement [1] with respect to temperature variance under conditions of a temperature of 50°C to 150°C, a frequency of 1 Hz, a rate of rise in the temperature of 10°C/min, and a mode of shear.

[0007]

The present invention [2] includes A sealable resin sheet for sealing an element, the sealable resin sheet containing thermosetting resin, wherein a ratio ($H^*_{\text{at 10 Hz}}/H^*_{\text{at 0.01 Hz}}$) of a complex viscosity $H^*_{\text{at 10 Hz}}$ at a frequency of 10 Hz to a complex viscosity $H^*_{\text{at 0.01 Hz}}$ at a frequency of 0.01 Hz is 0.0020 or less when the complex viscosity H^* of the sealable resin sheet is evaluated in a dynamic viscoelastic measurement [2] with respect to frequency variance under conditions of a temperature of 90°C, a frequency of 0.01 to 10 Hz, and a mode of shear.

[0008]

The present invention [3] includes the sealable resin sheet described in [1] or [2] above, wherein a temperature T corresponding to a second lowest complex viscosity $\eta^*_{\text{MIN at 50 to 150}^\circ\text{C}}$ at a temperature within a range of 50°C to 150°C is within a range of 80°C to 120°C in the dynamic viscoelastic measurement [1] with respect to temperature variance.

[0009]

The present invention [4] includes the sealable resin sheet described in [3] above, wherein a ratio (G''/G') of a loss shear elastic modulus G'' to a storage shear elastic modulus G' at the temperature T is 0.4 or less.

EFFECTS OF THE INVENTION

[0010]

As for the sealable resin sheet of the present invention, the ratio ($\eta^*_{\text{MIN at 80 to 120}^\circ\text{C}}/\eta^*_{\text{at 50}^\circ\text{C}}$) of the lowest complex viscosity $\eta^*_{\text{MIN at 80 to 120}^\circ\text{C}}$ at 80°C to 120°C to the complex viscosity $\eta^*_{\text{at 50}^\circ\text{C}}$ at 50°C is 0.170 or more, namely, high. Thus, the entry of the cured product between the element and board can be reduced when the cured produce is formed by disposing the sealable resin sheet on the element, forming a sealing body by pressing the sealable resin sheet and element, and heating the sealing body.

[0011]

As for the sealable resin sheet of the present invention, the ratio ($H^*_{\text{at 10 Hz}}/H^*_{\text{at 0.01 Hz}}$) of the complex viscosity $H^*_{\text{at 10 Hz}}$ at a frequency of 10 Hz to the complex viscosity $H^*_{\text{at 0.01 Hz}}$ at a frequency of 0.01 Hz is 0.0020 or less, namely, low. In other words, the sealable resin sheet has a high dependence on frequency at the shearing (pressing) of the sealable resin sheet. Thus, when the sealable resin sheet is disposed on the element and pressed, the shear by the press sufficiently reduces the complex viscosity of the sealable resin sheet. Hence, the peripheral edge of the gap between the element and board can surely be sealed. As a result, an excellent sealability to seal an element is achieved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

[FIG. 1] FIG. 1A to FIG. 1D are cross-sectional views illustrating the steps of producing an electronic element package by sealing a plurality of electronic elements with an embodiment of the sealable resin sheet of the present invention. FIG. 1A depicts the step of preparing the sealable resin sheet. FIG. 1B depicts the step of preparing the electronic elements. FIG. 1C depicts the step of forming a sealing body by pressing the sealable resin sheet. FIG. 1D depicts the step of forming a cured product by heating the sealing body.

[FIG. 2] FIG. 2A to FIG. 2D are cross-sectional views illustrating the step of producing an electronic element package by sealing a plurality of electronic elements with a sealing multi-layer resin sheet including the sealable resin sheet illustrated in FIG. 1A. FIG. 2A illustrates the step of preparing the sealing multi-layer resin sheet. FIG. 2B illustrates the step of preparing the electronic elements. FIG. 2C illustrates the step of forming a sealing body by pressing the sealing multi-layer resin sheet. FIG. 2D illustrates the step of forming a cured product by heating the sealing body.

[FIG. 3] FIG. 3A to FIG. 3D illustrate a method of measuring a sealing body entering length X and a cured product entering length Y of the sealing multi-layer resin sheet illustrated in FIG. 2A. FIG. 3A illustrates step A of forming a sample sheet from the sealing multi-layer resin sheet. FIG. 3B illustrates step B of preparing a dummy element. FIG. 3C illustrates step C of forming a sealing body by pressing the sealing multi-layer resin sheet. FIG. 3D illustrates step D of forming a cured product by heating the sealing body.

[FIG. 4] FIG. 4 illustrates a complex viscosity η^* -temperature curve in a dynamic viscoelastic measurement [1] with respect to temperature variance in each of Example 1 and Comparative Example 2.

[FIG. 5] FIG. 5 illustrates a complex viscosity H^* -frequency curve in a dynamic viscoelastic measurement [2] with respect to frequency variance in each of Example 1 and Comparative Example 2.

DESCRIPTION OF THE EMBODIMENTS

[0013]

<Sealable Resin Sheet>

An embodiment of the sealable resin sheet of the present invention is described.

[0014]

The sealable resin sheet is a resin sheet used to seal an element and has an approximately plate shape (film shape) extending in a surface direction orthogonal to a thickness direction. The sealable resin sheet contains thermosetting resin (described below).

[0015]

<Temperature Dependence of Sealable Resin Sheet>

In the dynamic viscoelastic measurement [1] with respect to temperature variance under the following conditions, the complex viscosity η^* of the sealable resin sheet is evaluated. The ratio of the complex viscosity η^* is described below.

Temperature: 50°C to 150°C

Frequency: 1 Hz

Rate of Temperature Increase: 10°C/min

Mode: Shear

[0016]

The lower limit of the ratio ($\eta^*_{\text{MIN at 80 to 120}^\circ\text{C}}/\eta^*_{\text{at 50}^\circ\text{C}}$) of the lowest complex viscosity $\eta^*_{\text{MIN at 80 to 120}^\circ\text{C}}$ at 80°C to 120°C to the complex viscosity $\eta^*_{\text{at 50}^\circ\text{C}}$ at 50°C is 0.170, preferably, 0.200, more preferably, 0.250, even more preferably, 0.300, particularly preferably, 0.350, most preferably, 0.400. The upper limit of the ratio ($\eta^*_{\text{MIN at 80 to 120}^\circ\text{C}}/\eta^*_{\text{at 50}^\circ\text{C}}$) of the lowest complex viscosity $\eta^*_{\text{MIN at 80 to 120}^\circ\text{C}}$ is, for example, 1.000, or 0.950.

[0017]

The temperature 50°C of the above-described “complex viscosity $\eta^*_{\text{at 50}^\circ\text{C}}$ at 50°C” corresponds to the temperature (sealing temperature) when the sealable resin sheet is pressed to seal the element or an approximate temperature to the sealing temperature.

[0018]

Similarly, the temperature 80 to 120°C of the above-described “lowest complex viscosity $\eta^*_{\text{MIN at 80 to 120}^\circ\text{C}}$ at 80 to 120°C” corresponds to the temperature (curing temperature) when the sealing body formed by the above-described press is heated or an approximate temperature to the curing temperature.

[0019]

The lower limit of the complex viscosity $\eta^*_{\text{at 50}^\circ\text{C}}$ at 50°C is, for example, 1,000 Pa·s, preferably, 5,000 Pa·s. The upper limit of the complex viscosity $\eta^*_{\text{at 50}^\circ\text{C}}$ at 50°C is, for example, 3,000,000 Pa·s, preferably, 1,000,000 Pa·s.

[0020]

The lower limit of the lowest complex viscosity $\eta^*_{\text{MIN at 80 to 120}^\circ\text{C}}$ at 80°C to 120°C is, for example, 500 Pa·s, preferably, 1,000 Pa·s. The upper limit of the lowest complex viscosity $\eta^*_{\text{MIN at 80 to 120}^\circ\text{C}}$ at 80°C to 120°C is, for example, 800,000 Pa·s, preferably, 500,000 Pa·s.

[0021]

In the dynamic viscoelastic measurement [1] with respect to temperature variance, the same sealable resin sheets are laminated in the thickness direction and the outer shape of the laminate is processed into a circular plate shape to produce a sample sheet. The complex viscosity η^* of the sample sheet is measured using a rheometer (viscoelasticity measuring instrument).

[0022]

The dynamic viscoelastic measurement [1] with respect to temperature variance is carried out to evaluate the temperature dependence of the sealable resin sheet. Specifically, the degree of the reduction in the complex viscosity of the sealable resin sheet at the heating of the sealable resin sheet is evaluated.

[0023]

In the dynamic viscoelastic measurement [1] with respect to temperature variance, as illustrated in FIG. 4, a complex viscosity η^* -temperature curve is obtained. The curve shows that the complex viscosity η^* reduces with the rise in the temperature and the complex viscosity reaches a minimum (the lowest complex viscosity η^*_{MIN}). Thereafter, with a further rise in the temperature, the complex viscosity increases. The degree of the reduction in the complex viscosity (the length of each arrow in FIG. 4) is evaluated using the reduction in the complex viscosity at the minimum.

[0024]

In the embodiment, a small degree of the reduction in the complex viscosity is preferred at the heating of the sealable resin sheet. A large absolute value of the complex viscosity η^* is also preferred.

[0025]

Specifically, the solid line referred to as Example 1 shows a smaller degree of the reduction in the complex viscosity at the minimum than the dotted line referred to as Comparative Example 2 does. This smaller degree can suppress the entering amount of the cured product at the heating. On the other hand, Comparative Example 2 shows a large degree of the reduction in the complex viscosity at the minimum. This large degree increases the entering amount of the cured product at the heating.

[0026]

In such a case, where the ratio ($\eta^*_{\text{MIN at 80 to 120}^\circ\text{C}}/\eta^*_{\text{at 50}^\circ\text{C}}$) of the lowest complex viscosity $\eta^*_{\text{MIN at 80 to 120}^\circ\text{C}}$ does not reach the above-described lower limit, the entry of the cured product between the element and board cannot sufficiently be reduced when the sealable resin sheet is disposed on the element and pressed to form a sealing body and the sealing body is heated to form the cured product.

[0027]

In the dynamic viscoelastic measurement [1] with respect to temperature variance, the lower limit of a temperature T, which corresponds to the second lowest complex viscosity η^*_{MIN} at 50 to 150°C at a temperature in a range of 50°C to 150°C, is, for example, 80°C, preferably, 85°C, more preferably, 90°C, even more preferably, 95°C, particularly preferably, 100°C. The upper limit of the temperature T corresponding to the second lowest complex viscosity η^*_{MIN} at 50 to 150°C is, for example, 120°C, preferably, 115°C, more preferably, 110°C, even more preferably, 105°C.

[0028]

When the temperature T corresponding to the second lowest complex viscosity η^*_{MIN} at 50 to 150°C is the above-described lower limit or more, the sealable resin sheet can keep its sheet shape at room temperature and sufficiently flow at the heating. When the temperature T corresponding to the second lowest complex viscosity η^*_{MIN} at 50 to 150°C is the above-described upper limit or less, the curing speed at which the sealable resin sheet is cured is not reduced, and thus the time of the production process (takt time) can be shortened.

[0029]

In particular, when the temperature T corresponding to the second lowest complex viscosity η^*_{MIN} at 50 to 150°C is within a range of 80°C to 120°C, the temperature T equals a temperature corresponding to the lowest complex viscosity η^*_{MIN} at 80 to 120°C at 80°C to 120°C. In other words, the second lowest complex viscosity η^*_{MIN} at 50 to 150°C is the same as the above-described lowest complex viscosity η^*_{MIN} at 80 to 120°C at 80°C to 120°C.

[0030]

In this manner, when actually being used, the sealable resin sheet can sufficiently flow and the curing speed of the sealable resin sheet is not reduced and the time of the production process (takt time) can be shortened.

[0031]

On the other hand, when the temperature T corresponding to the second lowest complex viscosity η^*_{MIN} at 50 to 150°C is less than 80°C as illustrated by the dashed-dotted line in FIG. 4, the curing speed of the sealable resin sheet is too high and the sealable resin sheet may not sufficiently flow when the sealable resin sheet is actually used.

[0032]

On the other hand, when the temperature T corresponding to the second lowest complex viscosity η^*_{MIN} at 50 to 150°C is more than 120°C as illustrated by the dashed-two dotted line in FIG. 4, the curing speed of the sealable resin sheet becomes low and the time of the production process (takt time) may not be shortened.

[0033]

The upper limit of the ratio (G''/G') of a loss shear elastic modulus G'' at the above-described temperature T to the storage shear elastic modulus G' at the same temperature T is, for example, 0.6, preferably, 0.5, more preferably, 0.45, even more preferably, 0.4, particularly preferably, 0.35. The lower limit of the ratio (G''/G') is, for example, 0.01, preferably, 0.1, more preferably, 0.15.

[0034]

When the ratio (G''/G') of the loss shear elastic modulus G'' (viscous term) to the storage shear elastic modulus G' (elastic term) is the above-described upper limit or less, the viscous term has a predetermined ratio or less to the elastic term. Thus, the entering amount of the cured product can be suppressed as much as possible at the curing temperature T or an approximate temperature to the curing temperature.

[0035]

<Frequency Dependence of Sealable resin sheet>

In the dynamic viscoelastic measurement [2] with respect to frequency variance under the following conditions, the complex viscosity H^* of the sealable resin sheet is evaluated. The ratio of the complex viscosity H^* is described below.

Temperature: 90°C

Frequency: 0.01 Hz to 10 Hz

Mode: Shear

[0036]

The upper limit of the ratio ($H^*_{\text{at 10 Hz}}/H^*_{\text{at 0.01 Hz}}$) of the complex viscosity $H^*_{\text{at 10 Hz}}$ at a frequency of 10 Hz to the complex viscosity $H^*_{\text{at 0.01 Hz}}$ at a frequency of 0.01 Hz is, for example, 0.0020, preferably, 0.0019, more preferably, 0.0017, even more preferably, 0.0015. The lower limit of the ratio ($H^*_{\text{at 10 Hz}}/H^*_{\text{at 0.01 Hz}}$) of the complex viscosity $H^*_{\text{at 10 Hz}}$ at a frequency of 10 Hz is, for example, 0.0001, preferably, 0.0005, more preferably, 0.0012.

[0037]

The lower limit of the complex viscosity $H^*_{\text{at } 0.01 \text{ Hz}}$ at a frequency of 0.01 Hz is, for example, 100,000 Pa·s, preferably, 200,000 Pa·s. The upper limit of the complex viscosity $H^*_{\text{at } 0.01 \text{ Hz}}$ at a frequency of 0.01 Hz is, for example, 50,000,000 Pa·s, preferably, 20,000,000 Pa·s.

[0038]

The lower limit of the complex viscosity $H^*_{\text{at } 10 \text{ Hz}}$ at a frequency of 10 Hz is, for example, 500 Pa·s, preferably, 1,000 Pa·s. The upper limit of the complex viscosity $H^*_{\text{at } 10 \text{ Hz}}$ at a frequency of 10 Hz is, for example, 500,000 Pa·s, preferably, 100,000 Pa·s.

[0039]

In the dynamic viscoelastic measurement [2] with respect to frequency variance, the same sealable resin sheets are laminated in the thickness direction and the outer shape of the laminate is processed into a circular plate shape to produce a sample sheet. The complex viscosity H^* of the sample sheet is measured using a rheometer (viscoelasticity measuring instrument).

[0040]

The dynamic viscoelastic measurement [2] with respect to frequency variance is carried out to evaluate the frequency dependence of the sealable resin sheet. Specifically, the measurement is carried out to evaluate the degree of the reduction in the complex viscosity of the sealable resin sheet when the shear stress on the sealable resin sheet at 90°C increases.

[0041]

The temperature 90°C is a temperature set to evaluate the frequency dependence of the sealable resin sheet. Specifically, a press temperature at which a sealing body is formed from the sealable resin sheet is assumed.

[0042]

Specifically, the dynamic viscoelastic measurement [2] with respect to frequency variance is carried out to evaluate the frequency dependence of the sealable resin sheet. Specifically, the dynamic viscoelastic measurement [2] with respect to frequency variance is carried out to evaluate the degree of the reduction in the complex viscosity of the sealable resin sheet at the shearing (press) (sealing).

[0043]

In the dynamic viscoelastic measurement [2] with respect to frequency variance, as illustrated in FIG. 5, a complex viscosity H^* -frequency curve is obtained. The curve shows that, with the increase in the frequency, the complex viscosity H^* reduces.

[0044]

The complex viscosity $H^*_{\text{at } 0.01 \text{ Hz}}$ at a frequency of 0.01 Hz is the complex viscosity before a shear stress is actually given to the sealable resin sheet. On the other hand, the complex viscosity $H^*_{\text{at } 10 \text{ Hz}}$ at a frequency of 10 Hz is the complex viscosity when a shear stress (for example, a high shear stress) (specifically, a press) is given to the sealable resin sheet.

[0045]

The degree of the reduction in the complex viscosity of the sealable resin sheet (the length of the arrow in FIG. 5) is preferably high (large) when the shear stress is given to the sealable resin sheet. In other words, for the embodiment, a small ratio ($H^*_{\text{at } 10 \text{ Hz}}/H^*_{\text{at } 0.01 \text{ Hz}}$) is preferred.

[0046]

Where the ratio ($H^*_{\text{at } 10 \text{ Hz}}/H^*_{\text{at } 0.01 \text{ Hz}}$) is the above-described upper limit or less, the complex viscosity is sufficiently reduced by the shearing on the sealable resin sheet when the sealable resin sheet is disposed on the element and pressed. Thus, the peripheral edges of the gap between the element and board can surely be sealed. When the shear stress at the heat curing is not given, the flow of the sealable resin sheet can be reduced.

[0047]

As illustrated in FIG. 1C, when a plurality of elements is disposed with a space therebetween in the surface direction, the complex viscosity is sufficiently reduced by the shearing that is applied on the sealable resin sheet when the sealable resin sheet is pressed. Thus, the sealable resin sheet enters between the elements and can cover the peripheral side surfaces of the elements.

[0048]

<Material (Composition) of Sealable Resin Sheet>

The sealable resin sheet contains the above-described thermosetting resin. Specifically, the material of the sealable resin sheet is a thermosetting resin composition containing thermosetting resin.

[0049]

Examples of the thermosetting resin include epoxy resin, silicone resin, urethane resin, polyimide resin, urea resin, melamine resin, and unsaturated polyester resin. These can be used alone or in combination of two or more.

[0050]

As the thermosetting resin, preferably, epoxy resin is used. The epoxy resin is prepared as an epoxy resin composition containing a main agent, a curing agent, and a curing accelerator.

[0051]

Examples of the main agent include: bifunctional epoxy resins such as bisphenol A epoxy resin, bisphenol F epoxy resin, modified bisphenol A epoxy resin, modified bisphenol F epoxy resin, and biphenyl epoxy resin; and trifunctional or more of multifunctional epoxy resins such as phenol novolak epoxy resin, cresol novolak epoxy resin, trishydroxyphenyl methane epoxy resin, tetraphenylol ethane epoxy resin, and dicyclopentadiene epoxy resin. These main agents can be used alone or in combination of two or more. As the main agent, preferably, a bifunctional epoxy resin, more preferably, a bisphenol F epoxy resin is used.

[0052]

The lower limit of the epoxy equivalent of the main agent is, for example, 10 g/eq., preferably, 100 g/eq.. The upper limit of the epoxy equivalent of the main agent is, for example, 300 g/eq., preferably, 250 g/eq..

[0053]

The lower limit of the softening point of the main agent is, for example, 50°C, preferably, 70°C, more preferably, 72°C, even more preferably, 75°C. The upper limit of the softening point of the main agent is, for example, 130°C, preferably, 110°C, more preferably, 90°C.

[0054]

When the softening point of the main agent is the above-described lower limit or more, a sealable resin sheet 1 can flow in the step illustrated in FIG. 1C. Thus, the time for the step illustrated in FIG. 1C can be shortened, and a one-side surface in the thickness direction of the sealable resin sheet 1 can be flattened in the step illustrated in FIG. 1C.

[0055]

The lower limit of the ratio of the main agent in the thermosetting resin composition is, for example, 1 mass%, preferably, 3 mass%, more preferably, 10 mass%. The upper limit of the ratio of the main agent in the thermosetting resin composition is, for example, 30 mass%, preferably, 15 mass%, more preferably, 12.5 mass%. The lower limit of the ratio of the main agent in the epoxy resin composition is, for example, 30 mass%, preferably, 50 mass%. The upper limit of the ratio of the main agent in the epoxy resin composition is, for example, 80 mass%, preferably, 70 mass%.

[0056]

The curing agent is a latent curing agent that cures the main agent by heating. Examples of the curing agent include phenol resins such as phenol novolak resin. When the curing agent is a phenol resin, a cured product of the phenol resin and main agent has high heat resistance and high chemical resistance. Accordingly, the cured product has excellent reliability for sealing.

[0057]

The ratio of the curing agent is set so that the following equivalent ratio holds. Specifically, the lower limit of the total amount of the hydroxyl group in the phenol resin with respect to 1 equivalent of the epoxy group in the main agent is, for example, 0.7 equivalent, preferably, 0.9 equivalent. The upper limit of the total amount of the hydroxyl group in the phenol resin with respect to 1 equivalent of the epoxy group in the main agent is, for example, 1.5 equivalent, preferably, 1.2 equivalent. Specifically, the lower limit of the contained amount of the curing agent with respect to 100 parts by mass of the main agent is, for example, 20 parts by mass, preferably, 40 parts by mass. The upper limit of the contained amount of the curing agent with respect to 100 parts by mass of the main agent is, for example, 80 parts by mass, preferably, 60 parts by mass.

[0058]

The curing accelerator is a catalyst (thermosetting catalyst) that promotes curing of the main agent by heating. Examples of the curing accelerator include organic phosphorus compounds and imidazole compounds such as 2-phenyl-4, 5-dihydroxy methyl imidazole (2PHZ-PW). Preferably, an imidazole compound is used. The lower limit of the contained

amount of the curing accelerator with respect to 100 parts by mass of the main agent is, for example, 0.05 parts by mass. The upper limit of the contained amount of the curing accelerator with respect to 100 parts by mass of the main agent is, for example, 0.05 parts by mass.

[0059]

The lower limit of the content ratio of the epoxy resin composition in the thermosetting resin composition (sealable resin sheet) is, for example, 5 mass%, preferably, 15 mass%, more preferably, 17 mass%. The upper limit of the content ratio of the epoxy resin composition in the thermosetting resin composition (sealable resin sheet) is, for example, 30 mass%, preferably, 25 mass%, more preferably, 20 mass%, even more preferably, 18 mass%.

[0060]

Preferably, the material of the sealable resin sheet further contains a layered silicate compound. The material of the sealable resin sheet is preferably a thermosetting resin composition containing thermosetting resin and a layered silicate compound.

[0061]

The layered silicate compound is dispersed into the thermosetting resin in the thermosetting resin composition (sealable resin sheet). The layered silicate compound works as a flow adjuster when a sealing body and a cured product (describe below) are formed from the sealable resin sheet. Specifically, the layered silicate compound is a flow reducer at the curing used to reduce the fluidity of the cured product when the sealable resin sheet is heated to form the cured product.

[0062]

The layered silicate compound is, for example, silicate salt having a structure (three-dimensional structure) in which layers each two-dimensionally extending (in the surface direction) are laminated in the thickness direction, and referred to as phyllosilicate.

[0063]

Specifically, examples of the layered silicate compound include: smectite such as montmorillonite, beidellite, non-tronite, saponite, hectorite, sauconite, and stevensite; kaolinite; halloysite; talc; and mica. To improve the mixability with the thermosetting resin, preferably, smectite is used as the layered silicate compound. More preferably, montmorillonite is used.

[0064]

The layered silicate compound may be an unmodified product of which surface is not modified. Alternatively, the layered silicate compound may be a modified product of which surface is modified by an organic component. To achieve excellent affinity with the thermosetting resin, preferably, the layered silicate compound has a surface modified by an organic component. Specifically, as the layered silicate compound, organic smectite having a surface modified by an organic component is used. More preferably, organic bentonite having a surface modified by an organic component is used.

[0065]

Examples of the organic component include organic cation (onium ion) such as ammonium, imidazolium, pyridinium, and phosphonium.

[0066]

Examples of the ammonium include dimethyl distearyl ammonium, distearyl ammonium, octadecylammonium, hexylammonium, octylammonium, 2-hexylammonium, dodecylammonium, and trioctylammonium. Examples of the imidazolium include methyl stearyl imidazolium, distearyl imidazolium, methylhexylimidazolium, dihexylimidazolium, methyloctylimidazolium, dioctylimidazolium, methyl dodecylimidazolium, and didodecylimidazolium. Examples of the pyridinium include stearyl pyridinium, hexylpyridinium, octylpyridinium, and dodecylpyridinium. Examples of the phosphonium include dimethyl distearyl phosphonium, distearyl phosphonium, octadecylphosphonium, hexylphosphonium, octylphosphonium, 2-hexylphosphonium, dodecylphosphonium, and trioctylphosphonium. These organic cations can be used alone or in combination of two or more. Preferably, ammonium, more preferably, dimethyl distearyl ammonium is used.

[0067]

As the organic layered silicate compound, preferably, organic smectite having a surface modified by ammonium is used. More preferably, organic bentonite having a surface modified by dimethyl distearyl ammonium is used.

[0068]

The lower limit of the average particle size of the layered silicate compound is, for example, 1 nm, preferably, 5 nm, more preferably, 10 nm. The upper limit of the average particle size of the layered silicate compound is, for example, 100 μm , preferably, 50 μm , more

preferably, 10 μm . The average particle size of the layered silicate compound is, for example, obtained as a D50 value (50% accumulation in median diameter) based on the particle size distribution obtained by a particle size distribution measurement method in a laser scattering method.

[0069]

A commercialized product can be used as the layered silicate compound. As an exemplary commercialized product of organic bentonite, the S-Ben series (manufactured by HOJUN.,Co.Ltd.) is used.

[0070]

The lower limit of the content ratio of the layered silicate compound in the thermosetting resin composition (sealable resin sheet) is, for example, 2 mass%, preferably, 3 mass%, more preferably, 3.5 mass%, even more preferably, 4 mass%, particularly preferably, 4.5 mass%. The upper limit of the content ratio of the layered silicate compound in the thermosetting resin composition (sealable resin sheet) is, for example, 25 mass%, preferably, 10 mass%, more preferably, 9 mass%, even more preferably, 7 mass%, particularly preferably, 6 mass%.

[0071]

When the content ratio of the layered silicate compound is the above-described lower limit or more, the ratio ($\eta^*_{\text{MIN at 80 to 120}^\circ\text{C}}/\eta^*_{\text{at 50}^\circ\text{C}}$) of the lowest complex viscosity $\eta^*_{\text{MIN at 80 to 120}^\circ\text{C}}$ to the complex viscosity $\eta^*_{\text{at 50}^\circ\text{C}}$ of the sealable resin sheet at 50°C can be set at the above-described lower limit or more.

[0072]

When the content ratio of the layered silicate compound is the above-described upper limit or less, the space (void) formed outside the side edges of the element can be reduced or the formation of the above-described void can be suppressed.

[0073]

The thermosetting resin composition can further contain an inorganic filler in addition to the layered silicate compound.

[0074]

Examples of the inorganic filler include: a silicate salt compound other than the layered silicate compound such as orthosilicate salt, sorosilicate salt, and inosilicate salt; and a silicon compound (other than the layered silicate compound) such as quartz (silicic acid), silica (anhydrous silicic acid), and silicon nitride. Examples of the inorganic filler further include alumina, aluminum nitride, and boron nitride. These can be used alone or in combination of two or more. Preferably, a silicate salt compound other than the layered silicate compound, more preferably, silica is used.

[0075]

The shape of the inorganic filler particles is not especially limited. Example thereof include an approximately spherical shape, an approximately plate shape, an approximately aciculate shape, and an amorphous shape. Preferably, an approximately spherical shape is used.

[0076]

The upper limit of the average value (average particle size in the case of an approximately spherical shape) of the maximum lengths of the inorganic filler particles is, for example, 50 μm , preferably, 20 μm , more preferably, 10 μm . The lower limit of the average value of the maximum lengths of the inorganic filler particles is, for example, 0.1 μm , preferably, 0.5 μm . The average particle size of the inorganic filler is, for example, obtained as a D50 value (50% accumulation in median diameter) based on the particle size distribution obtained by a particle size distribution measurement method in a laser scattering method.

[0077]

The inorganic filler can include a first filler and a second filler having an average value of the maximum lengths smaller than the average value of the maximum lengths of the first filler particles.

[0078]

The lower limit of the average value of the maximum lengths of the first filler particles is, for example, 1 μm , preferably, 3 μm . The upper limit of the average value of the maximum lengths of the first filler particles is, for example, 50 μm , preferably, 30 μm .

[0079]

The upper limit of the average value of the maximum lengths of the second filler particles is, for example, 0.9 μm , preferably, 0.8 μm . The lower limit of the average value of the maximum lengths of the second filler particles is, for example, 0.01 μm , preferably, 0.1 μm .
[0080]

The lower limit of the ratio of the average value of the maximum lengths of the first filler particles to the average value of the maximum lengths of the second filler particles is, for example, 2, preferably, 5. The upper limit of the ratio of the average value of the maximum lengths of the first filler particles to the average value of the maximum lengths of the second filler particles is, for example, 50, preferably, 20.
[0081]

The material of the first filler may be the same as or different from that of the second filler.
[0082]

In addition, the inorganic filler may have a surface partially or wholly treated with, for example, a silane coupling agent.
[0083]

The lower limit of the content ratio of the inorganic filler in the thermosetting resin composition (sealable resin sheet) is, for example, 50 mass%, preferably, 55 mass%, more preferably, 60 mass%, even more preferably, 65 mass%. The upper limit of the content ratio of the inorganic filler in the thermosetting resin composition (sealable resin sheet) is, for example, 90 mass%, preferably, 85 mass%, more preferably, 80 mass%, even more preferably, 75 mass%.
[0084]

The lower limit of the contained amount of the layered silicate compound with respect to 100 parts by mass of the inorganic filler is, for example, 1 part by mass, preferably, 2 parts by mass, more preferably, 3 parts by mass, even more preferably, 5 parts by mass. The upper limit of the contained amount of the layered silicate compound with respect to 100 parts by mass of the inorganic filler is, for example, 25 parts by mass, preferably, 20 parts by mass, more preferably, 15 parts by mass, even more preferably, 10 parts by mass.
[0085]

When the content ratio and/or contained amount of the inorganic filler is the above-described lower limit or more, the sealable resin sheet 1 can flow in the step illustrated in FIG. 1C.

[0086]

When the inorganic filler includes the first filler and second filler, the lower limit of the content ratio of the first filler in the thermosetting resin composition (sealable resin sheet) is, for example, 30 mass%, preferably, 40 mass% in the thermosetting resin composition. The upper limit of the content ratio of the first filler in the thermosetting resin composition (sealable resin sheet) is, for example, 60 mass%, preferably, 50 mass%. The lower limit of the contained amount of the second filler to 100 parts by mass of the first filler is, for example, 30 parts by mass, preferably, 40 parts by mass, more preferably, 50 parts by mass. The upper limit of the contained amount of the second filler to 100 parts by mass of the first filler is, for example, 70 parts by mass, preferably, 60 parts by mass, more preferably, 55 parts by mass.

[0087]

Another additive agent such as thermoplastic resin, a pigment, or a silane coupling agent can be added to the thermosetting resin composition.

[0088]

Examples of the thermoplastic resin include natural rubber, butyl rubber, isoprene rubber, chloroprene rubber, ethylene-vinyl acetate copolymer, ethylene-acrylic acid copolymer, ethylene-acrylate copolymer, polybutadiene resin, polycarbonate resin, thermoplastic polyimide resin, polyamide resin (6-nylon, 6,6-nylon, or the like), phenoxy resin, acrylic resin, saturated polyester resin (PET or the like), polyamide imide resin, fluorine resin, and styrene-isobutylene-styrene block copolymer. These thermoplastic resins can be used alone or in combination of two or more.

[0089]

To improve the dispersibility with the thermosetting resin, preferably, an acrylic resin is used as the thermoplastic resin.

[0090]

Examples of the acrylic resin include a carboxyl group-containing (meth)acrylate copolymer (preferably, carboxyl group-containing acrylate copolymer) obtained by polymerizing

a monomer component containing an alkyl (meth)acrylate having a straight-chain or branched alkyl group and another monomer (copolymerizable monomer).

[0091]

Examples of the alkyl group include an alkyl group having a carbon number of 1 to 6 such as methyl, ethyl, propyl, isopropyl, n-butyl, t-butyl, isobutyl, pentyl, and hexyl.

[0092]

Examples of the other monomer include carboxyl group-containing monomers such as acrylic acid, methacrylic acid, carboxyethyl acrylate, carboxypentyl acrylate, itaconic acid, maleic acid, fumaric acid, and crotonic acid.

[0093]

The lower limit of the weight average molecular weight of the thermoplastic resin is, for example, 100,000, preferably 300,000. The upper limit of the weight average molecular weight of the thermoplastic resin is, for example, 1,000,000, preferably 900,000. The weight average molecular weight is calibrated with standard polystyrene based on gel permeation chromatography (GPC).

[0094]

The ratio (solid content ratio) of the thermoplastic resin is adjusted so as not to block the thermal curing of the thermosetting resin. Specifically, the lower limit of the ratio (solid content ratio) of the thermoplastic resin in the thermosetting resin composition is, for example, 1 mass% or more, preferably 2 mass% or more. The upper limit of the ratio (solid content ratio) of the thermoplastic resin in the thermosetting resin composition is, for example, 10 mass%, preferably, 5 mass%.

[0095]

The thermoplastic resin may be prepared by being diluted with an appropriate solvent.

[0096]

Examples of the pigment include black pigments such as carbon black. The lower limit of the particle size of the pigment is, for example, 0.001 μm . The upper limit of the particle size of the pigment is, for example, 1 μm . The lower limit of the ratio of the pigment to the thermosetting resin composition is, for example, 0.1 mass%. The particle size of the pigment is an arithmetic average particle size obtained by observing the pigment with an electron

microscope. The upper limit of the ratio of the pigment to the thermosetting resin composition is, for example, 2 mass%.

[0097]

Examples of the silane coupling agent include a silane coupling agent containing an epoxy group. Examples of the silane coupling agent containing an epoxy group include: 3-glycidoxy dialkyl dialkoxy silanes such as 3-glycidoxy propyl methyl dimethoxy silane and 3-glycidoxy propyl methyl diethoxy silane; and 3-glycidoxy alkyl trialkoxy silanes such as 3-glycidoxy propyl trimethoxy silane and 3-glycidoxy propyl triethoxy silane. Preferably, a 3-glycidoxy alkyl trialkoxy silane is used. The lower limit of the content ratio of the silane coupling agent in the thermosetting resin composition is, for example, 0.1 mass%, preferably, 1 mass%. The upper limit of the content ratio of the silane coupling agent in the thermosetting resin composition is, for example, 10 mass%, preferably, 5 mass%.

[0098]

To produce the sealable resin sheet, the thermosetting resin composition is prepared by blending the above-described components in the above-described ratios.

[0099]

As necessary, a solvent (for example, ketone such as methyl ethyl ketone) is further blended, thereby preparing a varnish. Thereafter, the varnish is applied to a peeling sheet not illustrated and then dried by heating, thereby producing a sealable resin sheet having a sheet shape. Alternatively, without preparing a varnish, the sealable resin sheet can be formed from the thermosetting resin composition by kneading extrusion.

[0100]

The formed sealable resin sheet is B stage (a semi-cured state), and specifically in a state before C stage. In short, the formed sealable resin sheet is in a state before being completely cured. The sealable resin sheet is formed as a B-stage sheet from the thermosetting resin composition in A stage by heating in the above-described drying or by heating in the kneading extrusion.

[0101]

The lower limit of the thickness of the sealable resin sheet is, for example, 10 μm , preferably, 25 μm , more preferably, 50 μm . The upper limit of the thickness of the sealable

resin sheet is, for example, 3000 μm , preferably, 1000 μm , more preferably, 500 μm , even more preferably, 300 μm , particularly preferably, 100 μm .

[0102]

<Sealable Multi-layer Resin Sheet>

The sealable resin sheet may be included together with a second sealable resin sheet in a sealable multi-layer resin sheet.

[0103]

The sealable multi-layer resin sheet includes the sealable resin sheet, and the second sealable resin sheet sequentially at one side in the thickness direction. Specifically, the sealable multi-layer resin sheet includes the sealable resin sheet, and the second sealable resin sheet disposed on the whole of the one-side surface in the thickness direction of the sealable resin sheet. Preferably, the sealable multi-layer resin sheet includes only the sealable resin sheet and the second sealable resin sheet.

[0104]

The material of the second sealable resin sheet is, for example, the same as the material (thermosetting resin composition) of the sealable resin sheet. The material of the second sealable resin sheet is preferably the same as the material (thermosetting resin composition) of the sealable resin sheet except that the material of the second sealable resin sheet does not contain a layered silicate compound or contains a low concentration (for example, 1mass% or less) of a layered silicate compound.

[0105]

The objects of the dynamic viscoelastic measurement [1] with respect to temperature variance and/or dynamic viscoelastic measurement [2] with respect to frequency variance, such as the complex viscosities (η^* and H^*) of the second sealable resin sheet, are not especially limited and are appropriately set depending on the use or purpose of the sealable multi-layer resin sheet.

[0106]

The lower limit of the thickness of the second sealable resin sheet is, for example, 25 μm , preferably, 50 μm , more preferably, 100 μm , even more preferably, 150 μm . The upper limit of

the thickness of the second sealable resin sheet is, for example, 1000 μ m, preferably, 500 μ m, more preferably, 300 μ m.

[0107]

The sealable multi-layer resin sheet is prepared by bonding the sealable resin sheet and the second sealable resin sheet to each other.

[0108]

<Production of Electronic Element Package>

A method of producing an electronic element package by sealing electronic elements as exemplary elements with the sealable resin sheet is described with reference to FIG. 1A to FIG. 1D.

[0109]

(Example Using Sealable Resin Sheet)

In this method, as illustrated in FIG. 1A, first, a sealable resin sheet 1 is prepared. The sealable resin sheet 1 has a one-side surface and the other-side surface in thickness direction, which face each other in the thickness direction.

[0110]

As illustrated in FIG. 1B, an electronic element 21 is separately be prepared.

[0111]

The electronic element 21 includes an electronic component. For example, a plurality of electronic elements 21 is mounted on a board 22. The plurality of electronic elements 21 and board 22 are included together with bumps 23 on an element mounting board 24. In short, the element mounting board 24 includes the plurality of electronic elements 21, the board 22, and the bumps 23.

[0112]

The board 22 has an approximately flat plate shape extending in the surface direction. A one-side surface 25 in the thickness direction of the board 22 is provided with terminals (not illustrated) electrically connected to electrodes (not illustrated) of the electronic elements 21.

[0113]

Each of the electronic elements 21 has an approximately flat board shape (chip shape) extending in the surface direction. The electronic elements 21 are disposed with a space

therebetween in the surface direction. The other-side surfaces 28 in the thickness direction of the electronic elements 2 are parallel to the one-side surface 25 in the thickness direction of the board 22. The other-side surface 28 in the thickness direction of each of the electronic elements 21 is provided with an electrode (not illustrated). The electrodes of the electronic elements 21 are electrically connected to the terminals of the board 22 via the bumps 23 described next. The other-side surfaces 28 in the thickness direction of the electronic elements 21 are separated from the one-side surface 25 in the thickness direction of the board 22 with gaps (spaces) 26 therebetween.

[0114]

The lower limit of the interval (thickness-direction length) between the adjacent electronic elements 21 is, for example, 50 μm , preferably, 100 μm , more preferably, 200 μm . The upper limit of the interval between the adjacent electronic elements 21 is, for example, 10 mm, preferably, 5 mm, more preferably, 1 mm.

[0115]

The bumps 23 electrically connect the electrodes (not illustrated) of the electronic elements 21 to the terminals on the board 22, respectively. The bumps 23 are disposed between the electrodes of the electronic elements 21 and the terminals on the board 22. Examples of the material of the bumps 23 include metals such as a solder and gold. The bump 23 has a thickness corresponding to the thickness (height) of the gap 26. The thickness of the bump 23 is appropriately set, depending on the use or purpose of the element mounting board 24.

[0116]

Next, as illustrated in FIG. 1B, the sealable resin sheet 1 is disposed on the plurality of electronic elements 21. Specifically, the other-side surface in the thickness direction of the sealable resin sheet 1 is brought into contact with the one-side surfaces in the thickness direction of the electronic elements 21.

[0117]

Next, as illustrated in FIG. 1C, the sealable resin sheet 1 and the element mounting board 24 are pressed. Preferably, the sealable resin sheet 1 and element mounting board 24 are heat-pressed at a low temperature.

[0118]

For example, a press 27 having two flat plates presses the sealable resin sheet 1 and element mounting board 24, sandwiching them in the thickness direction. The flat plates of the press 27 include, for example, a heat source not illustrated.

[0119]

The conditions for the press (for example, pressure, time, and temperature) are not especially limited. The conditions allowing the sealable resin sheet 1 to enter between the electronic elements 21 and preventing the element mounting board 24 from being damaged are selected. More specifically, the conditions for the press are set so that a sufficient shear stress is given to the sealable resin sheet 1, and thus the sealable resin sheet 1 can flow and enter between the adjacent electronic elements 21, cover the side peripheral surface of each of the electronic elements 21, and be in contact with the one-side surface 25 in the thickness direction of the board 22 that does not overlap the electronic elements 21 in the plan view.

[0120]

Specifically, the lower limit of the pressure of the press is, for example, 0.05 MPa, preferably, 0.1 MPa. The upper limit of the pressure of the press is, for example, 10 MPa, preferably, 5 MPa. The lower limit of the time of the press is, for example, 0.3 minutes, preferably, 0.5 minutes. The upper limit of the time of the press is, for example, 10 minutes, preferably, 5 minutes.

[0121]

Specifically, the lower limit of the heating temperature is, for example, 40°C, preferably, 60°C. The upper limit of the heating temperature is, for example, 100°C, preferably, 95°C.

[0122]

When the sealable resin sheet 1 is pressed (is given the shear stress), the sealable resin sheet 1 plastically deforms corresponding in the outer shape of the electronic elements 21. The other-side surface in the thickness direction of the sealable resin sheet 1 deforms into a shape corresponding to the thickness-direction one-side surfaces and side peripheral surfaces of the electronic elements 21.

[0123]

The above-described deformation of the sealable resin sheet 1 by the press results from the fact that the sealable resin sheet 1 has a high dependence on frequency.

[0124]

The sealable resin sheet 1 plastically deforms while maintaining B stage.

[0125]

In this manner, the sealable resin sheet 1 covers the side peripheral surface of each of the electronic elements 21, and is in contact with the one-side surface 25 in the thickness direction of the board 22 that does not overlap the electronic elements 21 in the plan view.

[0126]

In this manner, a sealing body 31 sealing the electronic elements 21 is formed (produced) from the sealable resin sheet 1. A one-side surface in the thickness direction of the sealing body 31 is a flat surface.

[0127]

Thereafter, as illustrated in FIG. 1D, the sealing body 31 is heated, thereby forming a cured product 41 from the sealing body 31.

[0128]

Specifically, the sealing body 31 and element mounting board 24 are taken out of the press 27. Subsequently, the sealing body 31 and element mounting board 24 are heated under atmospheric pressure in a dryer.

[0129]

The lower limit of the heating temperature (curing temperature) is, for example, 100°C, preferably, 120°C. The upper limit of the heating temperature (curing temperature) is, for example, 200°C, preferably, 180°C. The lower limit of the heating time is, for example, 10 minutes, preferably, 30 minutes. The upper limit of the heating time is, for example, 180 minutes, preferably, 120 minutes.

[0130]

The above-described heating of the sealing body 31 forms the cured product 41 in C stage (completely cured) from the sealing body 31. A one-side surface in the thickness direction of the cured product 41 is an exposed surface.

[0131]

An edge of the sealing body 31 allowed to slightly enter the gap is further allowed to slightly enter the inside of the gap 26 and become the cured product 41 therein. The degree of the entry is suppressed as much as possible.

[0132]

The above-described suppression of the entry of the cured product 41 results from the fact that the sealable resin sheet 1 has a low dependence on temperature.

[0133]

As for the sealable resin sheet 1, the ratio ($\eta^*_{\text{MIN at 80 to 120}^\circ\text{C}}/\eta^*_{\text{at 50}^\circ\text{C}}$) of the lowest complex viscosity $\eta^*_{\text{MIN at 80 to 120}^\circ\text{C}}$ at 80°C to 120°C to the complex viscosity $\eta^*_{\text{at 50}^\circ\text{C}}$ at 50°C is 0.170 or more, namely, high. In other words, the temperature dependence of the sealable resin sheet 1 (sealing body 31) is low at the heat curing. Thus, the entry of the cured product 41 between the electronic element 21 and board 22 can be reduced when the sealable resin sheet 1 is disposed on the element 21 and pressed to form a sealing body 31 and the sealing body is heated to form the cured product 41.

[0134]

On the other hand, the ratio ($H^*_{\text{at 10 Hz}}/H^*_{\text{at 0.01 Hz}}$) of the complex viscosity $H^*_{\text{at 10 Hz}}$ at a frequency of 10 Hz to the complex viscosity $H^*_{\text{at 0.01 Hz}}$ at a frequency of 0.01 Hz is 0.0020 or less, namely, low. In other words, the sealable resin sheet 1 has a high dependence on frequency at the shearing (pressing) of the sealable resin sheet 1. The complex viscosity of the sealable resin sheet 1 is sufficiently reduced by the shearing of the press when the sealable resin sheet 1 is disposed and pressed on the electronic element 21. Thus, the peripheral edges of the gap 26 between the electronic element 21 and board 22 can surely be sealed.

[0135]

The lower limit of a temperature T, which corresponds to the second lowest complex viscosity $\eta^*_{\text{MIN at 50 to 150}^\circ\text{C}}$ within a range of temperatures 50°C to 150°C, is within a range of 80°C to 120°C. When actually being used, the sealable resin sheet can sufficiently flow. Meanwhile, the curing speed of the sealable resin sheet is not getting slow, and thus the curing does not take any longer time than conventional curing methods do.

[0136]

The ratio (G''/G') of the loss shear elastic modulus G'' at the above-described temperature T to the storage shear elastic modulus G' at the same temperature T is 0.4 or less. Thus, the entering amount of the cured product 41 can be suppressed as much as possible at the curing temperature T or an approximate temperature to the curing temperature.

[0137]

(Example Using Sealable Multi-layer Resin Sheet)

A method of producing an electronic element cured product package 50 by sealing the plurality of electronic elements 21 with the sealable multi-layer resin sheet 11 and subsequently forming the cured product 41 is described with reference to FIG. 2A to FIG. 2D.

[0138]

As illustrated in FIG. 2A, a sealable multi-layer resin sheet 11 is prepared. Specifically, a sealable resin sheet 1 and a second sealable resin sheet 12 are bonded to each other.

[0139]

As illustrated in FIG. 2B, the plurality of electronic elements 21 mounted on the board 22 is prepared.

[0140]

Subsequently, the sealable multi-layer resin sheet 11 is disposed on the electronic elements 21 so that the other-side surface in the thickness direction of the sealable resin sheet 1 is brought into contact with the one-side surfaces in the thickness direction of the electronic elements 21.

[0141]

As illustrated in FIG. 2C, thereafter, the sealable resin sheet 1 and the element mounting board 24 are pressed.

[0142]

The press makes the sealable resin sheet 1 flow and enter between the adjacent electronic elements 21. The above-described deformation of the sealable resin sheet 1 results from the fact that the sealable resin sheet 1 has a high dependence on frequency.

[0143]

On the other hand, the second sealable resin sheet 12 does not contain a layered silicate compound or contains a low concentration of a layered silicate compound. Thus, when the second sealable resin sheet 12 is pressed, the fluidity of the second sealable resin sheet 12 is not improved and maintained low. Hence, the entry of the second sealable resin sheet 12 between the adjacent electronic elements 21 is suppressed.

[0144]

In this manner, the sealing body 31 sealing the electronic elements 21 is formed from the sealable multi-layer resin sheet 11.

[0145]

When the sealable resin sheet 1 contains the inorganic filler in a ratio of the above-described lower limit or more and the second sealable resin sheet 12 contains the inorganic filler in a ratio of the above-described lower limit or more, the press illustrated in FIG. 2C can make both the sealable resin sheet 1 and second sealable resin sheet 12 flow.

[0146]

At that time, the sealable resin sheet 1 is in contact with the electronic elements 21 while the second sealable resin sheet 12 is located at a side opposite to the electronic elements 21 relative to the sealable resin sheet 1. In other words, an edge of the sealing body 31 that faces the gap 26 is formed from the sealable resin sheet 1. On the other hand, the one-side surface in the thickness direction of the sealing body 31 is formed from the second sealable resin sheet 12.

[0147]

Thereafter, as illustrated in FIG. 2D, the sealing body 31 is heated, thereby forming the cured product 41 from the sealing body 31.

[0148]

This sealable multi-layer resin sheet 11 can also have the same operations and effects as those of the above-described sealable resin sheet 1.

[0149]

In particular, when the sealable resin sheet 1 and the second sealable resin sheet 12 contain a main agent of epoxy resin having a softening point of 50°C or more and 130°C or less, the sealable resin sheet 1 and the second sealable resin sheet 12 can flow in the step illustrated in FIG. 2C. Thus, the time for the step illustrated in FIG. 2C can be shortened, and a one-side

surface in the thickness direction of the second sealable resin sheet 12 can be flattened in the step illustrated in FIG. 2C.

[0150]

Furthermore, when the sealable resin sheet 1 and the second sealable resin sheet 12 contain phenol resin as a curing agent together with the main agent of epoxy resin, the cured product 41 has a high heat resistance and a high chemical resistance. Accordingly, the cured product 41 has excellent reliability for sealing.

[0151]

In the step illustrated in FIG. 2C, the second sealable resin sheet 12 receives the pressing force and is fluidized. Thus, the one-side surface in the thickness direction of the second sealable resin sheet 12 is flattened. As described above, in the step illustrated in FIG. 2C, the sealable resin sheet 1 receives the pressing force, is softened and flows together with the second sealable resin sheet 12 in the sealable multi-layer resin sheet 11. Then, the sealable resin sheet 1 deforms, following the outer shapes of the electronic elements 21. In the step illustrated in FIG. 2C, the sealable resin sheet 1 is allowed to slightly enter the gap 26.

[0152]

In the step illustrated in FIG. 2D, the flow of the sealable resin sheet 1 is suppressed based on the reduction in complex viscosity η^* with the rise in temperature. Thus, an excessive entry of the sealable resin sheet 1 to the gap 26 is suppressed. In other words, the cured product 41 that is the cured sealable multi-layer resin sheet 11 including the sealable resin sheet 1 can reduce the cured product entering length Y.

[0153]

Variations

In each of the variations described below, the same members and steps as the above-described embodiment are given the same numerical references and the descriptions thereof are omitted. Further, each of the variations has the same operations and effects as those of the embodiment unless especially described otherwise. The embodiment and variations can appropriately be combined.

[0154]

Alternatively, the second sealable resin sheet 12 in the sealable multi-layer resin sheet 11 can have a plurality of layers.

[0155]

As an example of the element, the electronic elements 21 separated from the one-side surface 25 in the thickness direction of the board 22 with the gap 26 therebetween is described. Then, the electronic elements 21 are sealed with the sealable resin sheet 1. However, although not illustrated, for example, electronic elements 21 in contact with the one-side surface 25 in the thickness direction of the board 22 can be used. Then, the electronic elements 21 can be sealed with the sealable resin sheet 1 as well.

[0156]

As an example of the element, the electronic elements 21 are described. However, a semiconductor element can be used as well.

[0157]

Variations include a sealable resin sheet where the ratio ($H^*_{\text{at 10 Hz}}/H^*_{\text{at 0.01 Hz}}$) obtained by the dynamic viscoelastic measurement [2] with respect to frequency variance is 0.0020 or less whereas the ratio ($\eta^*_{\text{MIN at 80 to 120}^\circ\text{C}}/\eta^*_{\text{at 50}^\circ\text{C}}$) obtained by the dynamic viscoelastic measurement [1] with respect to temperature variance is less than 0.170.

Examples

[0158]

Hereinafter, with reference to Preparation Examples, Comparative Preparation Examples, Examples, and Comparative Examples, the present invention is more specifically described. The present invention is not limited to Preparation Examples, Comparative Preparation Examples, Examples, and Comparative Examples in any manner. The specific numeral values used in the description below, such as mixing ratios (contents), physical property values, and parameters can be replaced with the corresponding mixing ratios (contents), physical property values, parameters in the above-described "DESCRIPTION OF EMBODIMENTS", including the upper limit values (numeral values defined with "or less", and "less than") or the lower limit values (numeral values defined with "or more", and "more than").

[0159]

The components used in Preparation Examples and Comparative Preparation Examples are described as follows.

[0160]

Layered silicate compound: S-BEN NX manufactured by HOJUN Co., Ltd. (organic bentonite having a surface modified by dimethyl distearyl ammonium)

Main agent: YSLV-80XY manufactured by the new Nippon Steel Chemical Co., Ltd. (bisphenol F type epoxy resin, high-molecular-weight epoxy resin, epoxy equivalent of 200 g/eq., softening point of 80°C)

Curing agent: LVR- 8210DL manufactured by Gunei Chemical Industry Co., Ltd. (novolac-type phenol resin, latent curing agent, hydroxyl group equivalent: 104 g/eq., softening point: 60°C)

Curing accelerator: 2PHZ-PW manufactured by SHIKOKU CHEMICALS CORPORATION (2-phenyl-4,5-dihydroxymethylimidazole)

Acryl resin: HME-2006M manufactured by Negami Chemical Industrial Co., Ltd., a carboxyl group-containing acrylic acid ester copolymer (acrylic polymer), weight-average molecular weight: 600,000, glass-transition temperature (T_g): -35°C, methyl ethyl ketone solution with a 20 mass% solid content concentration

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

First filler: FB-8SM (spherical molten silica powder (inorganic filler), average particle size of 7.0 μm)

Second filler: an inorganic filler made of SC220G-SMJ manufactured by Admatechs Company Limited (average particle size of 0.5 μm) having a surface finished with 3-methacryloxypropyl trimethoxysilane (manufactured by Shin-Etsu Chemical Co., Ltd. product name: KBM- 503). Inorganic particles having a surface finished with 1 part by mass of a silane coupling agent with respect to 100 parts by mass of the inorganic filler.

Carbon black: #20 manufactured by Mitsubishi Chemical Corporation., particle size of 50 nm

[0161]

Preparation Examples 1 to 3 and Comparative Preparation Examples 1 and 2

A varnish of a thermosetting resin composition was prepared in conformity with the blending formula described in Table 1. The varnish was applied on a surface of a peeling sheet, and then dried at 120°C for 2 minutes, thereby producing a sealable resin sheet 1 with a thickness of 65 μm .

[0162]

A sealable resin sheet 1 with a thickness of 25 μm was separately produced as a thickness adjustment sheet.

[0163]

Each of the sealable resin sheets 1 was in B stage.

[0164]

Preparation Example 4

A varnish of a thermosetting resin composition was prepared in conformity with the blending formula described in Table 2. The varnish was applied on a surface of a peeling sheet, and then dried at 120°C for 2 minutes, thereby producing a second sealable resin sheet 12 with a thickness of 195 μm . The second sealable resin sheet 12 was in B stage.

[0165]

Examples 1 to 3 and Comparative Examples 1 and 2

In each of the combinations of Preparation Examples shown in Table 3, the sealable resin sheet and the second sealable resin sheet were adhered to each other, thereby producing a sealable multi-layer resin sheet with a thickness of 260 μm .

[0166]

Evaluation

The following including properties was evaluated. The results are shown in Table 1.

[0167]

A. Dynamic Viscoelastic Measurement [1] with respect to temperature variance

The dynamic viscoelastic measurement [1] with respect to temperature variance was carried out under the following conditions to evaluate the complex viscosity η^* of the sealable resin sheet of each of Preparation Example and Comparative Preparation Examples

Rheometer: MARS III (rotary) manufactured by HAAKE

Temperature: 50°C to 150°C

Frequency: 1 Hz

Rate of rise in temperature: 10°C/min

Mode: Shear

Strain: 0.05%

Jig: parallel plates

Distance between jigs: 800µm

Sample: A sample sheet that was prepared by laminating 15 sealable resin sheets with a thickness of 65 µm and a sealable resin sheet with a thickness of 25 µm in the thickness direction to produce a sample sheet with a thickness of 1000 µm, and then processing (cutting) the outer shape of the sample sheet into a circular plate shape with a diameter 8 mm

[0168]

The dynamic viscoelastic measurement [1] with respect to temperature variance was carried out to obtain the complex viscosity η^* at 50°C at 50°C, the lowest complex viscosity η^*_{MIN} at 80 to 120°C at 80°C to 120°C, the temperature T corresponding to the second lowest complex viscosity η^*_{MIN} at 50 to 150°C at a temperature within a range of 50°C to 150°C, and the loss shear elastic modulus G'' /storage shear elastic modulus G' .

[0169]

The complex viscosity η^* -temperature curve of each of Example 1 and Comparative Example 2 in the dynamic viscoelastic measurement [1] with respect to temperature variance is shown in FIG. 4.

[0170]

B. Dynamic Viscoelastic Measurement [2] with respect to frequency variance

The dynamic viscoelastic measurement [2] with respect to frequency variance was carried out under the following conditions to evaluate the complex viscosity H^* of the sealable resin sheet of each of Preparation Example and Comparative Preparation Examples

Rheometer: MARS III (rotary) manufactured by HAAKE

Temperature: 90°C

Frequency: 0.01 Hz to 10 Hz

Mode: Shear

Strain: 0.05%

Jig: parallel plates

Distance between jigs: 800 μm

Sample: A sample sheet that was prepared by laminating 15 sealable resin sheets with a thickness of 65 μm and a sealable resin sheet with a thickness of 25 μm in the thickness direction to produce a sample sheet with a thickness of 1000 μm , and then processing (cutting) the outer shape of the sample sheet into a circular plate shape with a diameter 8 mm

[0171]

Subsequently, the ratio ($H^*_{\text{at } 10 \text{ Hz}}/H^*_{\text{at } 0.01 \text{ Hz}}$) of the complex viscosity $H^*_{\text{at } 10 \text{ Hz}}$ at a frequency of 10 Hz to the complex viscosity $H^*_{\text{at } 0.01 \text{ Hz}}$ at a frequency of 0.01 Hz was obtained.

[0172]

The complex viscosity H^* -frequency curve of each of Example 1 and Comparative Example 2 in the dynamic viscoelastic measurement [2] with respect to frequency variance is shown in FIG. 5.

[0173]

(Measurement of Cured Product Entering Length Y)

The following Steps A to E were carried out as illustrated in FIG. 3A to FIG. 3D to measure the cured product entering length Y of the sealable multi-layer resin sheet 11 of each of Examples and Comparative Examples.

[0174]

Step A: As illustrated in FIG. 3A, a circular-plate-shaped sample sheet 61 with a diameter of 8 mm and a thickness of 1000 μm was prepared from the sealable resin sheet 1.

[0175]

Step B: As illustrated in FIG. 3B, a dummy element mounting board 74 was prepared by mounting a dummy element 71 with a longitudinal length of 3 mm, a lateral length of 3 mm, and a thickness of 200 μm on a glass board 72 through bumps 23 with a thickness of 20 μm .

[0176]

Step C: As illustrated in FIG. 3C, the sample sheet 61 sealed the dummy element 71 on the dummy element mounting board 74 by vacuum flat-plate press at a temperature of 65°C, a pressure of 0.1 MPa, a degree of vacuum of 1.6 kPa, and for a press time of 1 minute, thereby forming a sealing body 31 from the sample sheet 61.

[0177]

Step D: As illustrated in FIG. 3D, the sealing body 31 was heat-cured by heating at 150°C under atmospheric pressure for 1 hour, thereby forming a cured product 41 from the sealing body 31.

[0178]

Step E: As illustrated in an enlarged drawing of FIG. 3D, the cured product entering length Y in which the cured product 41 entered the gap 26 between the dummy element 71 and the glass board 72 from a side edge 75 was measured based on the side edge 75 of the dummy element 71.

[0179]

The dummy element 71 had an approximately flat board shape (chip shape) extending in the surface direction.

[0180]

The glass board 72 had an approximately flat board shape extending in the surface direction. The other-side surface in the thickness direction of the dummy element 71 and a one-side surface in the thickness direction of the glass board 72 was separated by a gap 26 with a thickness of 20 μm in a region that does not overlap the bumps 23 when being projected in the thickness direction.

[0181]

The dummy element mounting board 74 included the above-described dummy element 71, glass board 72, and bumps 23.

[0182]

Subsequently, by the following criteria, the cured product entering length Y was evaluated. The results are shown in Table 3.

Good: The cured product entering length Y was 0 μm or more and 20 μm or less.

Fair: The cured product entering length Y was more than 20 μm and 30 μm or less, or less than 0 μm and -5 μm or more.

Bad: The cured product entering length Y was more than 30 μm , or, less than -5 μm .

[0183]

In the evaluation, the “minus” means that a space protruding outward from the side edge 75 of the dummy element 71 was formed (see the thick dashed line in FIG. 3D). The absolute value of the “minus” corresponds to a length of the protruding space.

[0184]

<Measurement of Sealing Body Entering Length>

The following step F was additionally carried out between Steps C and D to measure the cured product entering length Y of the sealing multi-layer resin sheet 11 of each of Examples and Comparative Examples. The results are shown in Table 3.

[0185]

Step F: The sealing body entering length X in which the sealing body 31 entered the gap 26 between the dummy element 22 and the glass board 72 from the side edge 75 was measured based on the side edge 75 of the dummy element 71.

Good: The sealing body entering length X was 0 μm or more and 10 μm or less.

Fair: The sealing body entering length X was more than 10 μm and 20 μm or less, or less than 0 μm and -5 μm or more.

Bad: The sealing body entering length X was more than 20 μm or less than -5 μm .

[0186]

[Table 1]

Material of sealable resin sheet					Preparation Example 1	Preparation Example 2	Preparation Example 3	Comparative Preparation Example 1	Comparative Preparation Example 2
Layered silicate compound	Organic bentonite (modified by dimethyl distearyl ammonium)		S-BEN NX	(Part(s))	0.43	0.71	1.43	0.14	0
Content of layered silicate compound in sealable resin sheet					3	5	10	1	0
Parts of layered silicate compound to 100 parts of inorganic filler					4	7	14	1	0
Epoxy resin composition	Main agent	Epoxy resin	YSLV-80XY	(Part(s))	1.8	1.66	1.31	1.94	2.01
	Curing agent	Phenol resin	LVR-8210DL	(Part(s))	0.98	0.9	0.712	1.06	1.01
	Curing accelerator	Imidazole-type	2PHZ-PW	(Part(s))	0.026	0.024	0.02	0.028	0.029
Ratio of main agent in thermosetting resin composition					13	12	9	14	14
Ratio of main agent in epoxy resin composition					64	64	64	64	66
Parts of curing agent to 100 parts of main agent					54	54	54	55	50
Parts of curing accelerator to 100 parts of main agent					1.4	1.4	1.5	1.4	1.4
Content of epoxy resin composition in thermosetting resin composition					20	18	14	21	21
Thermoplastic resin	Acrylic polymer (solid content only)		HME-2006M	(Part(s))	0.79	0.73	0.58	0.84	0.87
Ratio of thermoplastic resin in thermosetting resin composition					6	5	4	6	6
Silane coupling agent	Glycidyl group-containing		KBM-403	(Part(s))	0.15	0.15	0.15	0.15	0.15
Content of silane coupling agent in thermosetting resin composition					1.0	1.1	1.0	1.1	1.1
Inorganic filler	First filler		FB-8SM	(Part(s))	6.5	6.5	6.5	6.5	6.5
	Second filler		SC220G-SMJ	(Part(s))	3.5	3.5	3.5	3.5	3.5
Content of inorganic filler					70	70	70	70	70
Content of first filler in thermosetting resin composition					45	46	45	46	46
Parts of second filler to 100 parts by mass of first filler					54	54	54	54	54
Pigment	Carbon black		#20	(Part(s))	0.1	0.1	0.1	0.1	0.1
Ratio of pigment to thermosetting resin composition					0.8	0.8	0.6	0.8	0.9
Dynamic viscoelastic measurement with respect to temperature dispersion [1]	The lowest complex viscosity η^*_{MIN} at 80 to 120°C / Complex viscosity $\eta^*_{\text{at 50}^\circ\text{C}}$				0.322	0.428	0.636	0.168	0.139
	Temperature T corresponding to the second lowest complex viscosity η^*_{MIN} at 50 to 150°C [°C]				103	102	105	112	109
	G'' / G' at temperature T				0.418	0.342	0.153	0.789	0.982
Dynamic viscoelastic measurement with respect to frequency dispersion [2]	Complex viscosity $H^*_{\text{at 10Hz}}$ / Complex viscosity $H^*_{\text{at 0.01Hz}}$				0.0019	0.0014	0.0011	0.0054	0.0080

[0187]

[Table 2]

Material of second sealable resin sheet					Comparative Preparation Example 4
Formula of thermosetting resin composition					
Epoxy resin composition	Main agent	Epoxy resin	YSLV-80XY	(Part(s))	1.84
	Curing agent	Phenol resin	LVR-8210DL	(Part(s))	1
	Curing accelerator	Imidazole-type	2PHZ-PW	(Part(s))	0.02
Ratio of main agent in thermosetting resin composition				[%]	7
Ratio of main agent in epoxy resin composition				[%]	64
Parts of curing agent to 100 parts of main agent				(Part(s))	54
Parts of curing accelerator to 100 parts of main agent				(Part(s))	1.1
Content of epoxy resin composition in thermosetting resin composition				[%]	11
Thermoplastic resin	Acrylic polymer (solid content only)		HME-2006M	(Part(s))	0.17
Ratio of thermoplastic resin in thermosetting resin composition				[%]	1
Silane coupling agent	Glycidyl group-containing		KBM-403	(Part(s))	0.35
Content of silane coupling agent in thermosetting resin composition				[%]	1
Inorganic filler	First filler		FB-8SM	(Part(s))	15.15
	Second filler		SC220G-SMJ	(Part(s))	8.16
Content of inorganic filler				[%]	87
Content of first filler in thermosetting resin composition				[%]	57
Parts of second filler to 100 parts by mass of first filler				(Part(s))	54
Pigment	Carbon black		#20	(Part(s))	0.1
Ratio of pigment to thermosetting resin composition				[%]	0.4

Formula of thermosetting resin composition

[0188]

[Table 3]

Sealable multi-layer resin sheet	Example 1	Example 2	Example 3	Comparative Example 1	Comparative Example 2
Second sealable resin sheet	Preparation Example 4	Preparation Example 4	Preparation Example 4	Preparation Example 4	Preparation Example 4
Sealable resin sheet	Preparation Example 1	Preparation Example 2	Preparation Example 3	Comparative Preparation Example 1	Comparative Preparation Example 2
Sealing body entering length	Good	Good	Fair	Bad	Bad
Cured product entering length	Fair	Good	Fair	Bad	Bad

[0189]

While the illustrative embodiments of the present invention are provided in the above description, such is for illustrative purpose only and it is not to be construed as limiting in any manner. Modification and variation of the present invention that will be obvious to those skilled in the art is to be covered by the following claims.

Industrial Applicability

[0190]

The sealable resin sheet is used to seal an element.

Description of Reference Numerals

[0191]

1 sealable resin sheet

21 electronic element

η^* at 50°C complex viscosity at 50°C

η^*_{MIN} at 80 to 120°C the lowest complex viscosity at 80°C to 120°C

H^* at 0.01 Hz complex viscosity at a frequency of 0.01 Hz

H^* at 10 Hz complex viscosity at a frequency of 10 Hz

η^*_{MIN} at 50 to 150°C the second lowest complex viscosity

T temperature

Claims

1. A sealable resin sheet for sealing an element, the sealable resin sheet containing thermosetting resin,
wherein a ratio ($\eta^*_{\text{MIN at 80 to 120}^\circ\text{C}}/\eta^*_{\text{at 50}^\circ\text{C}}$) of a lowest complex viscosity $\eta^*_{\text{MIN at 80 to 120}^\circ\text{C}}$ at 80°C to 120°C to a complex viscosity $\eta^*_{\text{at 50}^\circ\text{C}}$ at 50°C is 0.170 or more when the complex viscosity η^* of the sealable resin sheet is evaluated in a dynamic viscoelastic measurement [1] with respect to temperature variance under conditions of
a temperature of 50°C to 150°C,
a frequency of 1 Hz,
a rate of rise in the temperature of 10°C/min, and
a mode of shear.
2. The sealable resin sheet according to Claim 1, wherein a temperature T corresponding to a second lowest complex viscosity $\eta^*_{\text{MIN at 50 to 150}^\circ\text{C}}$ at a temperature within a range of 50°C to 150°C is within a range of 80°C to 120°C in the dynamic viscoelastic measurement [1] with respect to temperature variance.
3. The sealable resin sheet according to Claim 2, wherein a ratio (G''/G') of a loss shear elastic modulus G'' to a storage shear elastic modulus G' at the temperature T is 0.4 or less.
4. A sealable resin sheet for sealing an element, the sealable resin sheet containing thermosetting resin,
wherein a ratio ($H^*_{\text{at 10 Hz}}/H^*_{\text{at 0.01 Hz}}$) of a complex viscosity $H^*_{\text{at 10 Hz}}$ at a frequency of 10 Hz to a complex viscosity $H^*_{\text{at 0.01 Hz}}$ at a frequency of 0.01 Hz is 0.0020 or less when the complex viscosity H^* of the sealable resin sheet is evaluated in a dynamic viscoelastic measurement [2] with respect to frequency variance under conditions of
a temperature of 90°C,
a frequency of 0.01 Hz to 10 Hz, and
a mode of shear.

5. The sealable resin sheet according to Claim 4, wherein a temperature T corresponding to a second lowest complex viscosity η^*_{MIN} at 50 to 150°C at a temperature within a range of 50°C to 150°C is within a range of 80°C to 120°C in the dynamic viscoelastic measurement [1] with respect to temperature variance.
6. The sealable resin sheet according to Claim 5, wherein a ratio (G''/G') of a loss shear elastic modulus G'' to a storage shear elastic modulus G' at the temperature T is 0.4 or less.