

TITLE OF THE INVENTION

SEALABLE RESIN SHEET

TECHNICAL FIELD

[0001]

The present invention relates to a sealable resin sheet, in particular, to a sealable resin sheet used to seal an element.

BACKGROUND ART

[0002]

It has been known to form a cured product from a sealable sheet 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 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.

[0005]

The present invention provides a sealable resin sheet that can sufficiently seal the element and reduce the entry of a cured product that enters between an element exemplified by a semiconductor element or an electronic component and the board.

MEANS FOR SOLVING THE PROBLEM

[0006]

The present invention [1] includes a sealable resin sheet having: a viscosity ($\nu_{0.01}$) of 8×10^5 Pa·s or more at 85°C at a shear rate of 0.01 rad/sec; and a viscosity ($\nu_{0.1}$) of less than 8×10^5 Pa·s at 85°C at a shear rate of 0.1 rad/sec.

[0007]

The present invention [2] includes the sealable resin sheet described in [1] above, having: the viscosity ($\nu_{0.01}$) at 85°C at a shear rate of 0.01 rad/sec; and a viscosity (ν_{10}) at 85°C at a shear rate of 10 rad/sec, the viscosity ($\nu_{0.01}$) and viscosity (ν_{10}) satisfying a formula (1) given below.

$$\nu_{0.01}/\nu_{10} \geq 70 \quad (1)$$

The present invention [3] includes the sealable resin sheet described in [1] or [2] above, wherein the viscosity (ν_{10}) is 0.4×10^5 Pa·s or less at 85°C at a shear rate of 10 rad/sec.

EFFECTS OF THE INVENTION

[0008]

The sealable resin sheet has a viscosity ($\nu_{0.01}$) of 8×10^5 Pa·s or more at 85°C at a shear rate of 0.01 rad/sec and a viscosity of less than 8×10^5 Pa·s at 85°C at a shear rate of 0.1 rad/sec.

[0009]

Thus, the sealable resin sheet can sufficiently seal the element and reduce an entering amount of the cured product that enters between the element and board.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

[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 a first 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 second embodiment of the sealable resin sheet of the present invention. FIG. 2A illustrates the step of preparing the sealable 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 sealable 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 are cross-sectional views illustrating steps of a method of measuring a cured product entering length Y in Examples. FIG. 3A illustrates the step of preparing a sealable multi-layer resin sheet (Step A). FIG. 3B illustrates the step of preparing an electronic element (dummy element) (Step B). FIG. 3C illustrates the step of forming a sealing body by pressing the sealable multi-layer resin sheet (Step C). FIG. 3D illustrates the step of forming a cured product by heating the sealing body (Step D).

DESCRIPTION OF THE EMBODIMENTS

[0011]

The sealable resin sheet of the present invention has a viscosity of a predetermined value at 85°C at a predetermined shear rate in a viscoelasticity measurement described below.

[0012]

Hereinafter, the first embodiment of the sealable resin sheet (sealable resin sheet having a layer) is described.

[0013]

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.

[0014]

The material of the sealable resin sheet contains, for example, thermosetting resin and thermoplastic resin.

[0015]

Examples of the thermosetting resin include epoxy resin, silicone resin, urethane resin, polyimide resin, urea resin, melamine resin, and unsaturated polyester resin.

[0016]

These thermosetting resins can be used alone or in combination of two or more.

[0017]

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.

[0018]

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 epoxy resins 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.

[0019]

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..

[0020]

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.

[0021]

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. 2C.

[0022]

The lower limit of the ratio of the main agent in the material is, for example, 1 mass%, preferably, 2 mass%. The upper limit of the ratio of the main agent in the material is, for example, 30 mass%, preferably, 15 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%.

[0023]

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 a high heat resistance and a high chemical resistance. Accordingly, the cured product has excellent reliability for sealing.

[0024]

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.

[0025]

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, 5 parts by mass.

[0026]

The lower limit of the content ratio of the thermosetting resin in the material (sealable resin sheet) is, for example, 5 mass%, preferably, 10 mass%, more preferably, 13 mass%. The upper limit of the content ratio of the thermosetting resin in the material (sealable resin sheet) is, for example, 30 mass%, preferably, 25 mass%, more preferably, 20 mass%.

[0027]

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.

[0028]

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

[0029]

Examples of the acrylic resin include a (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).

[0030]

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.

[0031]

Examples of the other monomer include: carboxyl group-containing monomers such as acrylic acid, methacrylic acid, carboxyethyl acrylate, carboxy pentyl acrylate, itaconic acid, maleic acid, fumaric acid, and crotonic acid; glycidyl group-containing monomers such as

glycidyl acrylate, and glycidyl methacrylate; acid anhydride monomers such as maleic acid anhydride, and itaconic acid anhydride; hydroxy group-containing monomers such as (meth)acrylic acid 2-hydroxyethyl, (meth)acrylic acid 2-hydroxypropyl, (meth)acrylic acid 4-hydroxybutyl, (meth)acrylic acid 6-hydroxyhexyl, (meth)acrylic acid 8-hydroxyoctyl, (meth)acrylic acid 10-hydroxydecyl, and (meth)acrylic acid 12-hydroxylauryl or (4-hydroxymethylcyclohexyl)-methyl acrylate; sulfonic acid group-containing monomers such as styrenesulfonic acid, arylsulfonic acid, 2-(meth)acrylamide-2-methylpropanesulfonic acid, (meth)acrylamide propanesulfonic acid, sulfopropyl (meth)acrylate, and (meth)acryloyl oxynaphthalenesulfonic acid; phosphoric acid group-containing monomers such as 2-hydroxyethyl acryloyl phosphate; styrene monomers; and acrylonitriles. These can be used alone or in combination of two or more.

Preferably, a carboxyl group-containing monomer and a hydroxy group-containing monomer, more preferably, a carboxyl group-containing monomer is used.

[0032]

The other monomers can be used alone or in combination of two or more.

[0033]

More preferable examples of the thermoplastic resin include an acrylic resin containing a carboxyl group. Even more preferably, the thermoplastic resin consists of an acrylic resin containing a carboxyl group.

[0034]

The lower limit of the acid value of the acrylic resin containing a carboxyl group is, for example, 18, preferably, 25. The upper limit of the acid value of the acrylic resin is, 50, preferably, 40.

[0035]

Where the above-described acid value is the above-described lower limit or more, the fluidity of the sealable resin sheet can be reduced when the sealable resin sheet is heated to form a cured product (at the curing step described below). Further, an element or board where the entering amount of the cured product falls within a predetermined range can be provided when the sealable resin sheet is heated to form a cured product (at the curing step described below).

[0036]

Where the above-described acid value is the above-described upper limit or less, the fluidity of the sealable resin sheet can appropriately be reduced when the sealable resin sheet is heated to form a cured product (at the curing step described below). Thus, an element or board where the entering amount of the cured product falls within a predetermined range can be provided.

[0037]

The above-described acid value can be measured by an indicator titration method using a known potassium hydroxide.

[0038]

The lower limit of the glass transition temperature T_g of the thermoplastic resin is, for example, -70°C , preferably, -50°C , more preferably, -30°C . The upper limit of the glass transition temperature T_g of the thermoplastic resin is, for example, 0°C , preferably, 5°C , more preferably, -5°C . The glass transition temperature T_g is a theoretical value obtained by, for example, the Fox equation. A specific calculation method is described, for example, in Japanese Unexamined Patent Publication No. 2016-175976.

[0039]

The lower limit of the weight average molecular weight of the thermoplastic resin is, for example, 100,000, preferably, 300,000, more preferably, 1,000,000, even more preferably, 1,100,000. The upper limit of the weight average molecular weight of the thermoplastic resin is, for example, 1,400,000. The weight average molecular weight is calibrated with standard polystyrene based on gel permeation chromatography (GPC).

[0040]

The lower limit of the ratio of the thermoplastic resin in the material (sealable resin sheet) is, for example, 1 mass%, preferably, 5mass%, more preferably, 15mass%. The upper limit of the ratio of the thermoplastic resin in the material is, for example, 30mass%.

[0041]

The lower limit of the ratio of the thermoplastic resin to the total amount of the thermoplastic resin and thermosetting resin is, for example, 10mass%, preferably, 20mass%. The upper limit of the ratio of the thermoplastic resin to the total amount of the thermoplastic resin and thermosetting resin is, for example, 40 mass%, preferably, 30mass%.

[0042]

A layered silicate compound, an inorganic filler (other than the layered silicate compound), a pigment, a silane coupling agent, or another additive can further be added to the material.

[0043]

The layered silicate compound is dispersed into the thermosetting resin and thermoplastic resin (resin matrix) in the material (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.

[0044]

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.

[0045]

Specifically, examples of the layered silicate compound include: smectite such as montmorillonite, beidellite, nontronite, 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.

[0046]

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 and thermoplastic 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.

[0047]

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

[0048]

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, methyldodecylimidazolium, 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.

[0049]

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.

[0050]

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.

[0051]

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.

[0052]

The lower limit of the content ratio of the layered silicate compound in the material (sealable resin sheet) is, for example, 0.1 mass%, preferably, 1 mass%, more preferably, 2 mass%, more preferably, 3 mass%. The upper limit of the content ratio of the layered silicate compound in the material (sealable resin sheet) is, for example, 25 mass%, preferably, 15mass%, more preferably, 10mass%, even more preferably, 7 mass%.

[0053]

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.

[0054]

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.

[0055]

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.

[0056]

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

[0057]

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 .

[0058]

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, 0.02 μm , preferably, 0.1 μm .

[0059]

The upper limit of the average value of the maximum lengths of the third filler particles is, for example, 0.015 μm . The lower limit of the average value of the maximum lengths of the second filler particles is, for example, 0.001 μm , preferably, 0.01 μm .

[0060]

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.

[0061]

The lower limit of the ratio of the average value of the maximum lengths of the second filler particles to the average value of the maximum lengths of the third filler particles is, for example, 10, preferably, 20. The upper limit of the ratio of the average value of the maximum lengths of the second filler particles to the average value of the maximum lengths of the third filler particles is, for example, 60, preferably, 50.

[0062]

The materials of the first filler, second filler, and third filler may be the same or different from each other.

[0063]

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

[0064]

The lower limit of the content ratio of the inorganic filler in the material (sealable resin sheet) is, for example, 30 mass%, preferably, 40mass%. The upper limit of the content ratio of the inorganic filler in the material (sealable resin sheet) is, for example, 70mass%, preferably, 60mass%.

[0065]

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.

[0066]

When the inorganic filler includes the first filler and second filler (does not include the third filler), the lower limit of the content ratio of the first filler in the material (sealable resin sheet) is, for example, 20mass%, preferably, 30mass%. The upper limit of the content ratio of the first filler in the material (sealable resin sheet) is, for example, 60 mass%, preferably, 50 mass%. The lower limit of the content ratio of the second filler in the material (sealable resin sheet) is, for example, 10mass%, preferably, 15mass%. The upper limit of the content ratio of the second filler in the material (sealable resin sheet) is, for example, 30 mass%, preferably, 25 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.

[0067]

When the inorganic filler includes the first filler, second filler, and third filler, the lower limit of the content ratio of the first filler in the material (sealable resin sheet) is, for example, 20mass%, preferably, 30mass%. The upper limit of the content ratio of the first filler in the material (sealable resin sheet) is, for example, 60 mass%, preferably, 50 mass%. The lower limit of the content ratio of the second filler in the material (sealable resin sheet) is, for example,

10mass%, preferably, 15mass%. The upper limit of the content ratio of the second filler in the material (sealable resin sheet) is, for example, 30 mass%, preferably, 25 mass%. The lower limit of the content ratio of the third filler in the material (sealable resin sheet) is, for example, 1mass%, preferably, 3mass%. The upper limit of the content ratio of the third filler in the material (sealable resin sheet) is, for example, 10 mass%, preferably, 5 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. The lower limit of the contained amount of the third filler to 100 parts by mass of the second filler is, for example, 10 parts by mass, preferably, 15 parts by mass. The upper limit of the contained amount of the third filler to 100 parts by mass of the second filler is, for example, 40 parts by mass, preferably, 30 parts by mass.

[0068]

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 particle size of the pigment is an arithmetic average particle size obtained by observing the pigment with an electron microscope. The lower limit of the ratio of the pigment to the material is, for example, 0.1 mass%. The upper limit of the ratio of the pigment to the material is, for example, 2 mass%.

[0069]

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, 3-glycidoxy alkyl trialkoxy silane is used. The lower limit of the content ratio of the silane coupling agent in the material is, for example, 0.1 mass%, preferably, 0.5 mass%. The upper limit of the content ratio of the silane coupling agent in the material is, for example, 10 mass%, preferably, 5 mass%, more preferably 2 mass%.

[0070]

To produce the sealable resin sheet, the material is prepared by blending the above-described components in the above-described ratios. When the layered silicate compound is blended in the material, preferably, the above-described components are sufficiently stirred to uniformly disperse the layered silicate compound into the thermosetting resin and thermoplastic resin.

[0071]

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.

[0072]

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 material in A stage by heating in the above-described drying or by heating in the kneading extrusion.

[0073]

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 .

[0074]

Next, a method of producing an electronic element package 51 by sealing electronic elements as exemplary elements with the sealable resin sheet is described with reference to FIG. 1A to FIG. 1D.

[0075]

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.

[0076]

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

[0077]

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.

[0078]

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.

[0079]

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 21 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.

[0080]

The lower limit of the interval 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. When the interval between the adjacent electronic elements 21 is the above-described upper limit or less, the board 22 can mount more electronic elements 21. Thus, the space can be saved.

[0081]

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.

[0082]

Next, as illustrated in FIG. 1B, the sealable resin sheet 1 is disposed on the plurality of electronic elements 21 (disposing step). 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.

[0083]

Next, as illustrated in FIG. 1C, the sealable resin sheet 1 and the element mounting board 24 are pressed (pressing step). Preferably, the sealable resin sheet 1 and element mounting board 24 are heat-pressed.

[0084]

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.

[0085]

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 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.

[0086]

Specifically, the lower limit of the pressure of the press is, for example, 0.01 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.

[0087]

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.

[0088]

When the sealable resin sheet 1 is pressed, 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.

[0089]

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

[0090]

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.

[0091]

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.

[0092]

At that time, the sealing body 31 is allowed to slightly enter the gap 26 (between the electronic elements 21 and board 22). Specifically, the sealing body 31 is allowed to have a sealing body entering length X in which the sealing body 31 enters the gap 26 based on a side edge 75 of the electronic element 21 (see FIG. 3C).

[0093]

Specifically, the upper limit of the sealing body entering length X is, for example, 20 μm , preferably, 10 μm , more preferably, 5 μm , even more preferably, 3 μm , particularly preferably, 1 μm .

[0094]

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

[0095]

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.

[0096]

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.

[0097]

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.

[0098]

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. Specifically, the cured product 41 can reduce a value $(Y - X)$ (hereinafter, referred to as a sealing body entering amount $(Y - X)$), i.e., the difference when the sealing body entering length X is subtracted from a cured product entering length Y (see FIG. 3D) in which the cured product 41 enters the gap 26 based on the side edge 75 of the electronic elements 21.

[0099]

Specifically, the upper limit of the cured product entering length Y is, for example, 45 μm , preferably, 25 μm , more preferably, 20 μm , even more preferably, 10 μm , particularly preferably, 5 μm , most preferably, 1 μm . The lower limit of the cured product entering length Y is, for example, -25 μm , preferably, -10 μm , more preferably, -5 μm .

[0100]

The upper limit of the sealing body entering amount ($Y - X$) is, for example, 30 μm , preferably, 15 μm , more preferably, 10 μm , even more preferably, 5 μm , particularly preferably, 3 μm , most preferably, 1 μm .

[0101]

The sealable resin sheet 1 has a viscosity of a predetermined value at 85°C at a predetermined shear rate in a viscoelasticity measurement described in detail in Examples.

[0102]

Specifically, the lower limit of the viscosity ($\nu_{0.01}$) at 85°C at a shear rate of 0.01 rad/sec is $8 \times 10^5 \text{ Pa}\cdot\text{s}$, preferably, $10 \times 10^5 \text{ Pa}\cdot\text{s}$. The upper limit of the viscosity ($\nu_{0.01}$) at 85°C at a shear rate of 0.01 rad/sec is, for example, $25 \times 10^5 \text{ Pa}\cdot\text{s}$, preferably, $18 \times 10^5 \text{ Pa}\cdot\text{s}$.

[0103]

The upper limit of the viscosity ($\nu_{0.1}$) at 85°C at a shear rate of 0.1 rad/sec is less than $8 \times 10^5 \text{ Pa}\cdot\text{s}$, preferably, less than $5 \times 10^5 \text{ Pa}\cdot\text{s}$. The lower limit of the viscosity ($\nu_{0.1}$) at 85°C at a shear rate of 0.1 rad/sec is, for example, $1 \times 10^5 \text{ Pa}\cdot\text{s}$.

[0104]

Where the viscosity ($\nu_{0.01}$) at 85°C at a shear rate of 0.01 rad/sec is the above-described lower limit or more and the viscosity ($\nu_{0.1}$) at 85°C at a shear rate of 0.1 rad/sec is less than the above-described upper limit, the entering amount of the cured product 41 that enters the gaps 26 between the electronic elements 21 and board 22 can be reduced when the sealable resin sheet 1 is disposed on the electronic elements 21 and the sealable resin sheet 1 (sealing body 31) is heated to form the cured product 41 as illustrated in FIG. 1D.

[0105]

In detail, the sealable resin sheet 1 exhibits a high viscosity (specifically, the viscosity ($\nu_{0.01}$) at 85°C at a shear rate of 0.01 rad/sec is the above-described lower limit or more) when the shear force (shear rate) is low. When the shear force (shear rate) is high, the sealable resin

sheet 1 has a thixotropy that exhibits a low viscosity (specifically, the viscosity ($v_{0.1}$) at 85°C at a shear rate of 0.1 rad/sec is less than the above-described lower limit).

[0106]

The thixotropy can reduce the viscosity of the sealable resin sheet 1 at the sealing step (when the shear force (shear rate) is high). This allows the sealable resin sheet 1 to enter between the electronic elements 21. In contrast, at the curing step (when the shear force (shear rate) is low), the viscosity of the sealable resin sheet 1 can be increased. This can reduce the entering amount of the cured product 41 that enters the gaps 26 between the electronic elements 21 and board 22.

[0107]

On the other hand, where the viscosity ($v_{0.01}$) at 85°C at a shear rate of 0.01 rad/sec is less than the above-described lower limit, the fluidity of the sealable resin sheet 1 cannot be reduced when the sealable resin sheet is heated to form the cured product (at the curing step). As a result, when the sealable resin sheet is heated to form the cured product (at the curing step), the entering amount of the cured product that enters between the electronic elements and board cannot be reduced.

[0108]

When the viscosity ($v_{0.1}$) at 85°C at a shear rate of 0.1 rad/sec is the above-described upper limit or more, the sealable resin sheet 1 cannot enter between the electronic elements 21.

[0109]

The viscosity ($v_{0.01}$) at 85°C at a shear rate of 0.01 rad/sec and the viscosity ($v_{0.1}$) at 85°C at a shear rate of 0.1 rad/sec satisfy preferably the following formula (2), more preferably, the following formula (3), even more preferably the following formula (4).

$$v_{0.01}/v_{0.1} \geq 2 \quad (2)$$

$$v_{0.01}/v_{0.1} \geq 3 \quad (3)$$

$$v_{0.01}/v_{0.1} \geq 4 \quad (4)$$

The viscosity ($v_{0.01}$) at 85°C at a shear rate of 0.01 rad/sec and the viscosity ($v_{0.1}$) at 85°C at a shear rate of 0.1 rad/sec satisfy preferably the following formula (5), more preferably, the following formula (6).

$$v_{0.01}/v_{0.1} \leq 6 \quad (5)$$

$$v_{0.01}/v_{0.1} \leq 5 \quad (6)$$

When the viscosity ($v_{0.01}$) at 85°C at a shear rate of 0.01 rad/sec and the viscosity ($v_{0.1}$) at 85°C at a shear rate of 0.1 rad/sec satisfy the above-described formula (2), formula (3), or formula (4), a thixotropy enough to give the above-described effects can be developed.

[0110]

A viscosity (v_{10}) at 85°C at a shear rate of 10 rad/sec has an upper limit of, for example, 0.4×10^5 Pa·s, preferably, 0.2×10^5 Pa·s. The lower limit of the viscosity (v_{10}) at 85°C at a shear rate of 10 rad/sec is, for example, 0.01×10^5 Pa·s, preferably, 0.05×10^5 Pa·s.

[0111]

When the viscosity (v_{10}) at 85°C at a shear rate of 10 rad/sec is the upper limit or less, the viscosity of the sealable resin sheet 1 can be reduced at the sealing step (when the shear force (shear rate) is high). Thus, the sealable resin sheet 1 can enter between the electronic elements 21.

[0112]

The viscosity ($v_{0.01}$) at 85°C at a shear rate of 0.01 rad/sec and the viscosity (v_{10}) at 85°C at a shear rate of 10 rad/sec satisfy, preferably, the following formula (7), more preferably, the following formula (8), even more preferably, the following formula (9), particularly preferably, the following formula (10).

$$v_{0.01}/v_{10} \geq 40 \quad (7)$$

$$v_{0.01}/v_{10} \geq 70 \quad (8)$$

$$v_{0.01}/v_{10} \geq 100 \quad (9)$$

$$v_{0.01}/v_{10} \geq 120 \quad (10)$$

The viscosity ($v_{0.01}$) at 85°C at a shear rate of 0.01 rad/sec and the viscosity (v_{10}) at 85°C at a shear rate of 10 rad/sec satisfy, preferably, the following formula (11), more preferably, the following formula (12)

$$v_{0.01}/v_{10} \leq 200 \quad (11)$$

$$v_{0.01}/v_{10} \leq 150 \quad (12)$$

When the viscosity ($v_{0.01}$) at 85°C at a shear rate of 0.01 rad/sec and the viscosity (v_{10}) at 85°C at a shear rate of 10 rad/sec satisfy the above-described formula (7), formula (8), formula

(9), or formula (10) (preferably, the above-described formula (8)), a thixotropy enough to give the above-described effects can be developed.

[0113]

Next, a second embodiment (multi-layer sealable resin sheet) of the sealable resin sheet of the present invention is described.

[0114]

In the second embodiment, as illustrated in FIG. 2A to FIG. 2D, a sealable multi-layer resin sheet 11, which includes the sealable resin sheet 1 and a second sealable resin sheet 12 sequentially at one side in the thickness direction, seals the electronic element 21. Subsequently, the cured product 41 is formed.

[0115]

The sealable multi-layer resin sheet 11 includes the sealable resin sheet 1, and the second sealable resin sheet 12 disposed on the whole of the one-side surface in the thickness direction of the sealable resin sheet 1. Preferably, the sealable multi-layer resin sheet 11 includes only the sealable resin sheet 1 and the second sealable resin sheet 12.

[0116]

The material of the second sealable resin sheet 12 is the same as the material (thermosetting resin composition) of the sealable resin sheet 1, except that the material of the second sealable resin sheet 12 does not contain a layered silicate compound. The lower limit of the ratio of the thickness of the second sealable resin sheet 12 to the thickness of the sealable resin sheet 1 is, for example, 0.5, preferably, 1, more preferably, 2. The upper limit of the ratio of the thickness of the second sealable resin sheet 12 to the thickness of the sealable resin sheet 1 is, for example, 10, preferably, 5.

[0117]

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.

[0118]

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

[0119]

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

[0120]

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.

[0121]

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

[0122]

The press makes the sealable resin sheet 1, which has the above-described thixotropy, flow and enter between the adjacent electronic elements 21. On the other hand, when the second sealable resin sheet 12 is pressed, the fluidity of the second sealable resin sheet 12 does not drastically change and is maintained low. Hence, the entry of the second sealable resin sheet 12 between the adjacent electronic elements 21 is suppressed.

[0123]

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

[0124]

When the sealable resin sheet 1 contains the fillers in a ratio of the above-described lower limit or more and the second sealable resin sheet 12 contains the fillers 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.

[0125]

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.

[0126]

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

[0127]

The sealable multi-layer resin sheet 11 includes the above-described sealable resin sheet 1. Thus, the entering amount of the cured product 41 that enters the gap 26 can be reduced.

[0128]

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.

[0129]

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.

[0130]

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.

[0131]

Variations

In each of the variations described below, the same members and steps as the above-described first and second embodiments 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 first and second embodiments unless especially described otherwise. The first and second embodiments and variations can appropriately be combined.

[0132]

In the first embodiment, the one-layer sealable resin sheet 1 seals the electronic elements 21. Although not illustrated, however, (a laminate sheet of) a plurality of the sealable resin sheets 1 can seal the electronic elements 21.

[0133]

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

[0134]

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.

[0135]

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

Examples

[0136]

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").

[0137]

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

[0138]

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., solid, 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., solid, softening point: 60°C)

Acryl resin 1: HME-2006M manufactured by Negami Chemical Industrial Co.,Ltd., a carboxyl group-containing acrylic acid ester copolymer (acrylic polymer), acid value: 32, functional group: 736, weight-average molecular weight: 1,290,000, glass-transition temperature (Tg): -13.9°C, methyl ethyl ketone solution with a 20 mass% solid content concentration

Acryl resin 2: HME-2000M manufactured by Negami Chemical Industrial Co.,Ltd., a carboxyl group-containing acrylic acid ester copolymer (acrylic polymer), acid value: 20, functional group: 367, weight-average molecular weight: 1,030,000, glass-transition temperature (Tg): 3.7°C, methyl ethyl ketone solution with a 20 mass% solid content concentration

Acryl resin 3: HME-2004M manufactured by Negami Chemical Industrial Co.,Ltd., an acrylic acid ester copolymer (acrylic polymer), acid value: 0, functional group: 0, weight-average

molecular weight: 1,180,000, glass-transition temperature (T_g): -3°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

Third filler: AEROSIL 200 manufactured by NIPPON AEROSIL CO., LTD. (average particle size of 12 nm), hydrophilic silica fine particles

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

Solvent: methyl ethyl ketone (MEK)

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

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

A varnish of the material 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. The sealable resin sheet 1 was in B stage.

[0139]

Preparation Example 4

A varnish of the material 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.

[0140]

Examples 1 to 3 and Comparative Examples 1 and 3

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 .

[0141]

Evaluation

Steps A to E were carried out. Then, the cured product entering length Y was measured.

[0142]

Step A: As illustrated in FIG. 3A, a sample sheet 61 with a longitudinal length of 10 mm, a lateral length of 10 mm, and a thickness of 260 μm was prepared from the sealable multi-layer resin sheet 11 of each of Examples and Comparative Example.

[0143]

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 .

[0144]

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.

[0145]

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.

[0146]

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.

[0147]

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

Excellent: The cured product entering length Y was 0 μm or more and 25 μm or less.

Good: The cured product entering length Y was more than 25 μm and 45 μm or less, or less than 0 μm and -25 μm or more.

Bad: The cured product entering length Y was more than 45 μm , or, less than -25 μm .

[0148]

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. 2D). The absolute value of the “minus” corresponds to a length of the protruding space.

[0149]

<Measurement of Sealing Body Entering Length>

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

[0150]

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. The results are shown in Table 3.

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

Good: The sealing body entering length X was more than 10 μm and 20 μm or less.

Bad: The sealing body entering length X was more than 20 μm .

[0151]

<Sealing Body Entering Amount>

By subtracting the sealing body entering length X obtained by the above-described method from the cured product entering length Y obtained by the above-described method, the sealing body entering amount ($Y - X$) was calculated. The results are shown in Table 3.

Excellent: the sealing body entering amount ($Y - X$) was 0 μm or more and 15 μm or less.

Good: the sealing body entering amount ($Y - X$) was more than 15 μm and 30 μm or less.

Bad: the sealing body entering amount ($Y - X$) was more than 30 μm .

[0152]

<Viscoelasticity Measurement>

The viscoelasticity of the sealable resin sheet 1 (B stage) of each of Examples 1 to 3 and Comparative Examples 1 to 3 was measured.

[0153]

Specifically, the viscoelasticity measurement was carried out using a rheometer (MARS III) (the measurement conditions: using an 8 mm ϕ plate, a temperature of 85°C, and a strain rate of 0.005%). The results are shown in Table 3.

[0154]

Observation

Where the viscosity ($\nu_{0.01}$) at 85°C at a shear rate of 0.01 rad/sec was $8 \times 10^5 \text{ Pa} \cdot \text{s}$ or more and the viscosity ($\nu_{0.1}$) at 85°C at a shear rate of 0.1 rad/sec was less than $8 \times 10^5 \text{ Pa} \cdot \text{s}$ in each of Examples 1 to 3 and the viscosity ($\nu_{0.01}$) at 85°C at a shear rate of 0.01 rad/sec was less than $8 \times 10^5 \text{ Pa} \cdot \text{s}$ in each of Comparative Examples 1 and 2, it was found that the sealing body entering length and sealing body entering amount of each of Examples 1 to 3 were smaller than those of each of Comparative Examples 1 and 2. In Comparative Example 3 in which the viscosity ($\nu_{0.1}$) at 85°C at a shear rate of 0.1 rad/sec was $8 \times 10^5 \text{ Pa} \cdot \text{s}$ or more, the sealable resin sheet failed to enter between the dummy elements.

[0155]

The findings have concluded that, when the viscosity ($\nu_{0.01}$) at 85°C at a shear rate of 0.01 rad/sec was $8 \times 10^5 \text{ Pa} \cdot \text{s}$ or more and the viscosity ($\nu_{0.1}$) at 85°C at a shear rate of 0.1 rad/sec was less than $8 \times 10^5 \text{ Pa} \cdot \text{s}$, the elements can sufficiently be sealed and the entering amount of the cured product between the elements and board can be reduced.

[0156]

[Table 1]

Preparation Example No.			Preparation Example 1	Preparation Example 2	Preparation Example 3	Comparative Preparation Example 1	Comparative Preparation Example 2	Comparative Preparation Example 3
Thermosetting resin	Epoxy resin	YSLV-80XY	(part(s))	7.5	7.5	7.5	9.1	7
	Phenol resin	LVR-8210DL	(part(s))	4.1	4.1	4.1	4.9	3.8
Thermoplastic resin	Acrylic resin (20%)	HME-2006M	(part(s))	-	18.5	-	22.2	22.5
		HME-2000M	(part(s))	18.5	-	-	-	-
		HME-2004M	(part(s))	-	-	18.5	-	-
Layered silicate compound	Organic bentonite (modified by dimethyl distearyl ammonium)	S-BEN NX	(part(s))	3.3	3.3	-	-	-
Silane coupling agent	Glycidyl group-containing	KBM-403	(part(s))	0.7	0.7	0.7	0.7	0.7
First filler	Silica	FB-8SM	(part(s))	30.2	30.2	30.2	30.2	30.2
Second filler	Silica	SC220G-SMJ	(part(s))	16.2	16.2	16.2	16.2	16.2
Third filler	Silica	AEROSIL200	(part(s))	-	3.3	-	-	3.3
Curing accelerator	Imidazole series	2PHZ-PW	(part(s))	0.1	0.1	0.1	0.1	0.1
Solvent	Organic solvent	MEK	(part(s))	3.9	3.9	3.9	1	0.7
Pigment	Carbon black	#20	(part(s))	0.5	0.5	0.5	0.6	0.5
Thickness			(μm)	65	65	65	65	65

[Table 2]

Preparation Example No.				Preparation Example 4
Thermoplastic resin	Epoxy resin	YSLV-80XY	Ratio (%) to Material	5.3
	Phenol resin	LVR-8210DL	Ratio (%) to Material	2.9
Thermoplastic resin	Acrylic resin (20%)	HME-2006M	Ratio (%) to Material	2.5
Silane coupling agent	Glycidyl group-containing	KBM-403	Ratio (%) to Material	1.0
First filler	Silica	FB-8SM	Ratio (%) to Material	44.1
Second filler	Silica	SC220G-SMJ	Ratio (%) to Material	23.8
Curing accelerator	Imidazole series	2PHZ-PW	Ratio (%) to Material	0.1
Solvent	Organic solvent	MEK	Ratio (%) to Material	20.0
Pigment	Carbon black	#20	Ratio (%) to Material	0.3
Thickness [μm]			(μm)	195

[0158]

[Table 3]

Example/Comparative Example No.				Example 1	Example 2	Example 3	Comparative Example 1	Comparative Example 2	Comparative Example 3
Sealable multi-layer resin sheet	Sealable resin sheet			Preparation Example 1	Preparation Example 2	Preparation Example 3	Comparative Preparation Example 1	Comparative Preparation Example 2	Comparative Preparation Example 3
	Second sealable resin sheet			Preparation Example 4	Preparation Example 4	Preparation Example 4	Preparation Example 4	Preparation Example 4	Preparation Example 4
Evaluation	Viscosity at 85° C	Shear rate 0.01[rad/s]	$\times 10^5$ [Pa·s]	11.7	11.5	20	6	1.2	30
		Shear rate 0.1[rad/s]	$\times 10^5$ [Pa·s]	2.8	3	7	1.4	0.4	9
		Shear rate 10[rad/s]	$\times 10^5$ [Pa·s]	0.09	0.1	0.4	0.12	0.02	0.6
		Ratio of 0.01 to 10	-	130	115	50	50	60	50
	Cured product entering length Y			Excellent	Excellent	Excellent	Bad	Bad	※
	Sealing body entering length X			Excellent	Excellent	Good	Good	Good	
	Sealing body entering amount (Y – X)			Excellent	Excellent	Good	Bad	Bad	

※Sealable resin sheet failed to sufficiently enter between the dummy elements

[0159]

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

[0160]

The sealable resin sheet is used to seal an element.

Description of Reference Numerals

[0161]

1 sealable resin sheet

Claims

1. A sealable resin sheet comprising:
thermosetting resin;
5 thermoplastic resin; and
a layered silicate compound,
wherein the thermoplastic resin is an acrylic resin containing a carboxyl group,
wherein the acrylic resin containing a carboxyl group has an acid value of 18 or
more,
10 wherein the sealable resin sheet has:
a viscosity ($\nu_{0.01}$) of 8×10^5 Pa·s or more at 85°C at a shear rate of 0.01
rad/sec; and
a viscosity ($\nu_{0.1}$) of less than 8×10^5 Pa·s at 85°C at a shear rate of 0.1
rad/sec, and
15 wherein the layered silicate compound is organic bentonite.
2. The sealable resin sheet according to Claim 1, having:
the viscosity ($\nu_{0.01}$) at 85°C at a shear rate of 0.01 rad/sec; and a viscosity (ν_{10}) at
85°C at a shear rate of 10 rad/sec, the viscosity ($\nu_{0.01}$) and viscosity (ν_{10}) satisfying a
20 formula (1) given below.

$$\nu_{0.01}/\nu_{10} \geq 70 \quad (1)$$
3. The sealable resin sheet according to Claim 1, wherein
the viscosity (ν_{10}) is 0.4×10^5 Pa·s or less at 85°C at a shear rate of 10 rad/sec.