

TITLE OF THE INVENTION

SEALABLE MULTI-LAYER RESIN SHEET

TECHNICAL FIELD

[0001]

The present invention relates to a sealable multi-layer resin sheet, in particular, to a sealable multi-layer resin sheet for sealing 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 multi-layer resin sheet that can reduce entry of a cured product 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 multi-layer resin sheet comprising: a first sealable resin sheet; and a second sealable resin sheet sequentially toward one side in a thickness direction, wherein the first sealable resin sheet contains a layered silicate compound and a first inorganic filling material, the second sealable resin sheet contains a second inorganic filling material, a content ratio (B) of the first inorganic filling material to the first sealable resin sheet is 50 mass% or more, a content ratio (A) of the second inorganic filling material to the second sealable resin sheet is 60 mass% or more, and the content ratio (B) of the first inorganic filling material to the first sealable resin sheet and the content ratio (A) of the second inorganic filling material to the second sealable resin sheet satisfy a formula (1) described below.

$$0.4A + 1.7B < 160 \quad (1)$$

[0007]

The present invention [2] includes the sealable multi-layer resin sheet described in [1] above, wherein the first sealable resin sheet has a thickness of 30 μm or more and 100 μm or less, and the second sealable resin sheet has a thickness of 50 μm or more and 500 μm or less..

[0008]

The present invention [3] includes the sealable multi-layer resin sheet described in [1] or [2] above, wherein the first sealable resin sheet has a coefficient of linear expansion of 80 $\text{ppm}/^\circ\text{C}$ or less, and the second sealable resin sheet has a coefficient of linear expansion of 50 $\text{ppm}/^\circ\text{C}$ or less.

EFFECTS OF THE INVENTION

[0009]

In the sealable multi-layer resin sheet of the present invention, the first sealable resin sheet contains the layered silicate compound and first inorganic filling material. The second sealable resin sheet contains the second inorganic filling material.

[0010]

The content ratio (B) of the first inorganic filling material to the first sealable resin sheet and the content ratio (A) of the second inorganic filling material to the second sealable resin sheet have a predetermined ratio.

[0011]

The content ratio (B) of the first inorganic filling material to the first sealable resin sheet and the content ratio (A) of the second inorganic filling material to the second sealable resin sheet have a predetermined relationship.

[0012]

Thus, when the sealable multi-layer resin is disposed on an element and heated to form a cured product, an entering amount of the cured product that enters between the element and board can be reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

[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 multi-layer resin sheet of the present invention. FIG. 1A depicts the step of preparing the sealable multi-layer 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 multi-layer resin sheet. FIG. 1D depicts the step of forming a cured product by heating the sealing body.

[FIG. 2] FIG. 2 is a graph showing the relationship between a content ratio (B) of a first inorganic filling material to a first sealable resin sheet 1 and a content ratio (A) of a second inorganic filling material to a second sealable resin sheet 12.

[FIG. 3] FIG. 3A to FIG. 3D are cross-sectional views illustrating the 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).

[FIG. 4] FIG. 4 is a graph showing the relationship between a content ratio (B) of the first inorganic filling material to a first material and content ratio (A) of the second inorganic filling material to a second material in each of Examples 1 to 33 and Comparative Examples of 1 to 23.

DESCRIPTION OF THE EMBODIMENTS

[0014]

The sealable multi-layer resin sheet of the present invention 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.

[0015]

The sealable multi-layer resin sheet sequentially includes a first sealable resin sheet and a second sealable resin sheet toward one side in a thickness direction.

[0016]

In detail, the sealable multi-layer resin sheet includes the first sealable resin sheet and the second sealable resin sheet formed on a one-side surface in the thickness direction of the first sealable resin sheet. Preferably, the sealable multi-layer resin sheet consists of the first sealable resin sheet and the second sealable resin sheet.

[0017]

The first sealable resin sheet has an approximately plate shape (film shape) extending in the surface direction orthogonal to the thickness direction.

[0018]

The material of the first sealable resin sheet (hereinafter, referred to as the first material) contains a layered silicate compound and a first inorganic filling material.

[0019]

When the first material contains a first resin component (resin matrix) described below, the layered silicate compound is dispersed in the first resin component. The layered silicate compound works as a flow adjuster when a sealing body and a cured product (describe below) are formed from the first 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 first sealable resin sheet is heated and cured to form the cured product.

[0020]

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.

[0021]

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.

[0022]

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 the 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.

[0023]

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

[0024]

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.

[0025]

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.

[0026]

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.

[0027]

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.

[0028]

The lower limit of the content ratio of the layered silicate compound in the first material is, for example, 1 mass%, preferably, 3 mass%. The upper limit of the content ratio of the layered silicate compound in the first material is, for example, 15 mass%, preferably, 10 mass%.

[0029]

The first inorganic filling material is an inorganic filler other than the layered silicate compound. Examples thereof 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 first inorganic filling material 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.

[0030]

The shape of the first inorganic filling material 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.

[0031]

The upper limit of the average value (average particle size in the case of an approximately spherical shape) of the maximum lengths of the first inorganic filling material 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 first inorganic filling material particles is, for example, 0.1 μm , preferably, 0.5 μm . The average particle size of the first inorganic filling material particles 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.

[0032]

The first inorganic filling material 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.

[0033]

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 .

[0034]

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 .

[0035]

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.

[0036]

As long as the above ratios are within the above-described ranges, the entering amount of the cured product that enters between the element and board can further be reduced.

[0037]

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

[0038]

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

[0039]

The content ratio (B) of the first inorganic filling material to the first material is described below.

[0040]

Although described in detail below, the content ratio (B) of the first inorganic filling material to the first material has a predetermined relationship with the content ratio (A) of the second inorganic filling material to the second material (described below).

[0041]

The lower limit of the contained amount of the first inorganic filling material with respect to 100 parts by mass of the layered silicate compound is, for example, 1000 parts by mass, preferably, 1050 parts by mass, more preferably, 1100 parts by mass, even more preferably, 1150 parts by mass, particularly preferably, 1200 parts by mass, most preferably, 1250 parts by mass. The upper limit of the contained amount of the first inorganic filling material with respect to 100 parts by mass of the layered silicate compound is, for example, 1500 parts by mass, preferably, 1450 parts by mass, more preferably, 1400 parts by mass, even more preferably, 1350 parts by mass.

[0042]

When the contained amount of the first inorganic filling material with respect to 100 parts by mass of the layered silicate compound is within the above-described range (for example,

1000 to 1500 parts by mass), the entering amount of the cured product that enters between the element and board can further be reduced. When the contained amount of the first inorganic filling material with respect to 100 parts by mass of the layered silicate compound is within the above-described range (for example, 1000 to 1500 parts by mass), the entering amount of the cured body between the elements and board can be regulated at an appropriate value.

[0043]

When the first inorganic filling material includes the first filler and the second filler, the lower limit of the content ratio of the first filler in the first material is, for example, 32.5 mass%, preferably, 33 mass%, more preferably, 36 mass%, even more preferably, 40 mass%. The upper limit of the content ratio of the first filler in the first material is, for example, 52 mass%, preferably, 50 mass%, more preferably, 47 mass%, even more preferably, 43 mass%. The lower limit of the content ratio of the second filler in the first material is, for example, 1 mass%, preferably, 18 mass%, more preferably, 20 mass%, even more preferably, 22 mass%. The upper limit of the content ratio of the second filler in the first material is, for example, 26.5 mass%, preferably, 25 mass%, more preferably, 24 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.

[0044]

The first material preferably contains the first resin component as the resin matrix.

[0045]

The first resin component contains thermosetting resin and thermoplastic resin. Preferably, the first resin component consists of thermosetting resin and thermoplastic resin.

[0046]

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

[0047]

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

[0048]

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.

[0049]

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, dicyclopentadiene epoxy resin, and glycidyl amine epoxy resin (triglycidyl amino phenol). 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.

[0050]

The lower limit of the epoxy equivalent of the main agent is, for example, 10 g/eq., preferably, 80 g/eq.. The upper limit of the epoxy equivalent of the main agent is, for example, 300 g/eq., preferably, 250 g/eq..

[0051]

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.

[0052]

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, a one-side surface in the thickness direction of the sealable resin sheet 1 can be flattened in the step illustrated in FIG. 1C.

[0053]

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

[0054]

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 and tris hydroxyphenylmethane-type 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.

[0055]

These curing agents can be used alone or in combination of two or more. As the curing agent, preferably, phenol novolak resin and tris hydroxyphenylmethane-type novolak resin are used in combination.

[0056]

When phenol novolak resin and tris hydroxyphenylmethane-type novolak resin are used in combination, the lower limit of the content ratio of the phenol novolak resin to 100 parts by mass of the total amount of the phenol novolak resin and tris hydroxyphenylmethane-type novolak resin is, for example, 10 parts by mass. The upper limit of the content ratio of the phenol novolak resin to 100 parts by mass of the total amount of the phenol novolak resin and tris hydroxyphenylmethane-type novolak resin is, for example, 30 parts by mass. The lower limit of the content ratio of the tris hydroxyphenylmethane-type novolak resin to 100 parts by mass of the total amount of the phenol novolak resin and tris hydroxyphenylmethane-type novolak resin is, for example, 70 parts by mass. The upper limit of the content ratio of the tris hydroxyphenylmethane-type novolak resin to 100 parts by mass of the total amount of the phenol novolak resin and tris hydroxyphenylmethane-type novolak resin is, for example, 90 parts by mass.

[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, 5 parts by mass.

[0059]

The lower limit of the content ratio of the thermosetting resin in the first material is, for example, 10 mass%, preferably, 13 mass%, more preferably, 16 mass%, even more preferably, 20 mass%. The upper limit of the content ratio of the thermosetting resin in the first material is, for example, 37 mass%, preferably, 33 mass%, more preferably, 30 mass%, even more preferably, 25 mass%.

[0060]

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.

[0061]

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

[0062]

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).

[0063]

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.

[0064]

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 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, carboxyl group-containing monomers and hydroxy group-containing monomers, more preferably, carboxyl group-containing monomers are used.

[0065]

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

[0066]

More preferably, as the thermoplastic resin, an acrylic resin containing a carboxyl group is used. Even more preferably, the thermoplastic resin consists of an acrylic resin containing a carboxyl group.

[0067]

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.

[0068]

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).

[0069]

The lower limit of the ratio of the thermoplastic resin in the first material is, for example, 1 mass%, preferably, 2mass%, more preferably, 3mass%. The upper limit of the ratio of the thermoplastic resin in the first material is, for example, 7mass%, preferably, 6mass%, more preferably, 5mass%.

[0070]

The lower limit of the ratio of the thermoplastic resin to the total amount of the thermoplastic resin and thermosetting resin is, for example, 5mass%, preferably, 10mass% in the first sealable resin sheet. The upper limit of the ratio of the thermoplastic resin to the total amount of the thermoplastic resin and thermosetting resin is, for example, 30 mass%, preferably, 20mass% in the first sealable resin sheet.

[0071]

Another additive such as a pigment, or a silane coupling agent can further be added to the first material.

[0072]

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 first material is, for example, 0.1 mass%. The upper limit of the ratio of the pigment to the first material is, for example, 2 mass%.

[0073]

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 first 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 first material is, for example, 10 mass%, preferably, 5 mass%.

[0074]

The lower limit of the glass transition temperature T_g of the first material is, for example, 100°C, preferably, 120°C, more preferably, 145°C, even more preferably, 150°C. The upper limit of the glass transition temperature T_g of the thermoplastic resin is, for example, 180°C, preferably, 160°C.

[0075]

The second sealable resin sheet has an approximately plate shape (film shape) extending in the surface direction orthogonal to the thickness direction.

[0076]

The second sealable resin sheet is bonded to the first sealable resin sheet so that the whole of the other-side surface in the thickness direction of the second sealable resin sheet is in contact with the whole of the one-side surface in the thickness direction of the first sealable resin sheet.

[0077]

The material of the second sealable resin sheet (hereinafter, referred to as the second material) does not include a layered silicate compound and includes a second inorganic filling material.

[0078]

Examples of the second inorganic filling material include the same as the above-described examples of the first inorganic filling material. Preferably, silica is used.

[0079]

The average value (average particle size in the case of an approximately spherical shape) of the maximum lengths of the second inorganic filling material particles is the same as the above-described average value of the maximum lengths of the first inorganic filling material.

[0080]

Similarly to the first inorganic filling material, the second inorganic filling material 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.

[0081]

The average value of the maximum lengths of the first filler and average value of the maximum lengths of the second filler in the second inorganic filling material are the same as those in the first inorganic filling material.

[0082]

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

[0083]

The content ratio (A) of the second inorganic filling material to the second material is described below.

[0084]

Although described in detail below, the content ratio (B) of the first inorganic filling material to the first material has a predetermined relationship with the content ratio (A) of the second inorganic filling material to the second material.

[0085]

When the second inorganic filling material includes the first filler and second filler, the lower limit of the content ratio of the first filler in the second material is, for example, 38 mass%, preferably, 40 mass%, more preferably, 50 mass%, even more preferably, 52 mass%, particularly preferably, 54 mass%. The upper limit of the content ratio of the first filler in the second material is, for example, 60 mass%, preferably, 56 mass%. The lower limit of the content ratio of the second filler in the second material is, for example, 20 mass%, preferably, 22 mass%, more preferably, 25 mass%, even more preferably, 28 mass%. The upper limit of the content ratio of the second filler in the second material is, for example, 35 mass%, preferably, 30 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.

[0086]

The second material preferably includes a second resin component as the resin matrix.

[0087]

The second resin component contains thermosetting resin and thermoplastic resin. Preferably, the second resin component consists of thermosetting resin and thermoplastic resin.

[0088]

Examples of the thermosetting resin include the thermosetting resins exemplified in the description of the first resin component. 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. The thermosetting resins can be used alone or in combination of two or more.

[0089]

Examples of the main agent include the main agents exemplified in the description of the first resin component.

[0090]

The main agents can be used singly or in combination of two or more. Preferably, bifunctional epoxy resin and trifunctional or more of multifunctional epoxy resin are used in combination. More preferably, bifunctional epoxy resin and trifunctional epoxy resin are used

in combination. Even more preferably, bisphenol F epoxy resin and glycidyl amine epoxy resin are used in combination.

[0091]

When bifunctional epoxy resin and trifunctional epoxy resin are used in combination as the main agent, the lower limit of the ratio of the bifunctional epoxy resin to 100 parts by mass of the total amount of the bifunctional epoxy resin and trifunctional epoxy resin is, for example, 40 parts by mass. The upper limit of the ratio of the bifunctional epoxy resin to 100 parts by mass of the total amount of the bifunctional epoxy resin and trifunctional epoxy resin is, for example, 60 parts by mass. The lower limit of the ratio of the trifunctional epoxy resin to 100 parts by mass of the total amount of the bifunctional epoxy resin and trifunctional epoxy resin is, for example, 40 parts by mass. The upper limit of the ratio of the trifunctional epoxy resin to 100 parts by mass of the total amount of the bifunctional epoxy resin and trifunctional epoxy resin is, for example, 60 parts by mass.

[0092]

The epoxy equivalent and softening point of the main agent fall within the same ranges exemplified in the description of the first resin component.

[0093]

The lower limit of the ratio of the main agent in the second material is, for example, 4 mass%, preferably, 6 mass%. The upper limit of the ratio of the main agent in the second material is, for example, 20 mass%, preferably, 15 mass%, more preferably, 10 mass%, even more preferably, 8 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%.

[0094]

Examples of the curing agent include the curing agents exemplified in the description of the first resin component. Preferably, phenol novolak resin is used.

[0095]

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, more preferably, 60 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, 85 parts by mass.

[0096]

Examples of the thermoplastic resin include the thermoplastic resins exemplified in the description of the first resin component. Preferably, an acrylic resin, more preferably, an acrylic resin containing a carboxyl group is used.

[0097]

The lower limit of the ratio of the thermoplastic resin in the second material is, for example, 0.1 mass%, preferably, 0.6 mass%. The upper limit of the ratio of the thermoplastic resin in the second material is, for example, 1.5 mass%, preferably, 5 mass%.

[0098]

The lower limit of the ratio of the thermoplastic resin to the total amount of the thermoplastic resin and thermosetting resin in the second sealable resin sheet is, for example, 1 mass%, preferably, 5 mass%. The upper limit of the ratio of the thermoplastic resin to the total amount of the thermoplastic resin and thermosetting resin in the second sealable resin sheet is, for example, 20 mass%, preferably, 10 mass%.

[0099]

Another additive such as a pigment, or a silane coupling agent can further be added to the second material.

[0100]

Examples of the pigment include the pigments exemplified in the description of the first material.

[0101]

The particle size of the pigment falls within the same range as exemplified in the description of the first material.

[0102]

The lower limit of the ratio of the pigment to the second material is, for example, 0.1 mass%. The upper limit of the ratio of the pigment to the second material is, for example, 2 mass%.

[0103]

Examples of the silane coupling agent include the silane coupling agents exemplified in the description of the first material. Preferably, a 3-glycidoxy alkyl trialkoxy silane is used. The lower limit of the content ratio of the silane coupling agent in the second 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 second material is, for example, 10 mass%, preferably, 5 mass%, more preferably, 2 mass%.

[0104]

The second material has a glass-transition temperature lower than the glass-transition temperature of the first material. The lower limit of the glass-transition temperature of the second material is, for example, 100°C, preferably, 130°C. The upper limit of the glass-transition temperature of the second material is, for example, 160°C, preferably, 150°C.

[0105]

To obtain the sealable multi-layer resin sheet, each of the first sealable resin sheet and the second sealable resin sheet is produced.

[0106]

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

[0107]

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 first sealable resin sheet having a sheet shape. Alternatively, without preparing a varnish, the first sealable resin sheet can be formed from the first material by kneading extrusion.

[0108]

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

[0109]

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

[0110]

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 second sealable resin sheet having a sheet shape. Alternatively, without preparing a varnish, the second sealable resin sheet can be formed from the second material by kneading extrusion.

[0111]

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

[0112]

Next, to obtain the sealable multi-layer resin sheet, the second sealable resin sheet is disposed (transferred) at one side in the thickness direction of the first sealable resin sheet.

[0113]

In this manner, the sealable multi-layer resin sheet is obtained.

[0114]

In the sealable multi-layer resin sheet, the lower limit of the thickness of the first sealable resin sheet is, for example, 10 μm , preferably, 25 μm , more preferably, 30 μm . The upper limit of the thickness of the first sealable resin sheet is, for example, 3000 μm , preferably,

1000 μm , more preferably, 500 μm , even more preferably, 300 μm , particularly preferably, 100 μm .

[0115]

Meanwhile, the lower limit of the thickness of the second sealable resin sheet is, for example, 10 μm , preferably, 30 μm , more preferably, 50 μm . The upper limit of the thickness of the second sealable resin sheet is, for example, 3000 μm , preferably, 1000 μm , more preferably, 500 μm .

[0116]

The lower limit of the ratio of the thickness of the second sealable resin sheet to the thickness of the first sealable resin sheet is, for example, 0.5, preferably, 1, more preferably, more than 1. The upper limit of the ratio of the thickness of the second sealable resin sheet to the thickness of the first sealable resin sheet is, for example, 20, preferably, 10, more preferably, 5.

[0117]

The lower limit of the thickness of the sealable multi-layer resin sheet is, for example, 20 μm , preferably, 30 μm , more preferably, 50 μm . The upper limit of the thickness of the sealable multi-layer resin sheet is, for example, 6000 μm , preferably, 3000 μm , more preferably, 1500 μm , even more preferably, 1000 μm , particularly preferably, 500 μm , most preferably, 300 μm .

[0118]

Preferably, the first sealable resin sheet has a thickness within a specific range in the above-described range, and the second sealable resin sheet has a thickness within a specific range in the above-described range.

[0119]

Specifically, the second sealable resin sheet has a thickness larger than that of the first sealable resin sheet. In detail, when the lower limit of the thickness of the first sealable resin sheet is, for example, 30 μm , preferably, 40 μm and the upper limit of the thickness of the first sealable resin sheet is, for example, 100 μm , preferably, 70 μm ; the lower limit of the thickness of the second sealable resin sheet is, for example, 50 μm and the upper limit of the thickness of the second sealable resin sheet is, 500 μm , preferably, 300 μm . The lower limit of the thickness

of the sealable multi-layer resin sheet is, for example, 80 μm , preferably, 100 μm , more preferably, 200 μm . The upper limit of the thickness of the sealable multi-layer resin sheet is, for example, 600 μm , preferably, 300 μm .

[0120]

In such a case, a warp of the sealable multi-layer resin sheet is suppressed. Discharge of the first inorganic filling material from the first sealable resin sheet is suppressed.

[0121]

The upper limit of the coefficient of linear expansion of the first sealable resin sheet is, 90 $\text{ppm}/^{\circ}\text{C}$, preferably, 80 $\text{ppm}/^{\circ}\text{C}$, more preferably, 75 $\text{ppm}/^{\circ}\text{C}$, even more preferably, 70 $\text{ppm}/^{\circ}\text{C}$, particularly preferably, 60 $\text{ppm}/^{\circ}\text{C}$. The upper limit of the coefficient of linear expansion of the first sealable resin sheet is preferably low. However, when the upper limit of the coefficient of linear expansion of the first sealable resin sheet is too low, the amount of the first inorganic filling material excessively increases and thus the forming properties of the sheet reduces. The lower limit of the coefficient of linear expansion of the first sealable resin sheet may be, for example, 20 $\text{ppm}/^{\circ}\text{C}$.

[0122]

The upper limit of the coefficient of linear expansion of the second sealable resin sheet is, for example, 50 $\text{ppm}/^{\circ}\text{C}$, preferably, 40 $\text{ppm}/^{\circ}\text{C}$, more preferably, 20 $\text{ppm}/^{\circ}\text{C}$. The upper limit of the coefficient of linear expansion of the second sealable resin sheet is preferably low. However, when the upper limit of the coefficient of linear expansion of the second sealable resin sheet is too low, the amount of the second inorganic filling material excessively increases and thus the forming properties of the sheet reduces. The lower limit of the coefficient of linear expansion of the second sealable resin sheet may be, for example, 5 $\text{ppm}/^{\circ}\text{C}$.

[0123]

When the coefficient of linear expansion of the first sealable resin sheet is the above-described upper limit or less and the coefficient of linear expansion of the second sealable resin sheet is the above-described upper limit or less, a warp of the sealable multi-layer resin sheet can be suppressed.

[0124]

A method of measuring the above-described coefficient of linear expansion is described in detail in Example below.

[0125]

Next, a method of producing an electronic element package 50 by sealing electronic elements as exemplary elements with the sealable resin sheet is described with reference to FIG. 1A to FIG. 1D.

[0126]

In this method, as illustrated in FIG. 1A, a sealable multi-layer resin sheet 11 subsequently including a first sealable resin sheet 1 and a second sealable resin sheet 12 toward one side in the thickness direction is prepared (Preparation step). The sealable multi-layer resin sheet 11 has a one-side surface and the other-side surface in thickness direction, which face each other in the thickness direction.

[0127]

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

[0128]

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 the 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.

[0129]

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.

[0130]

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.

[0131]

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.

[0132]

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.

[0133]

Next, as illustrated in FIG. 1B, the sealable multi-layer resin sheet 11 is disposed on the plurality of electronic elements 21 (disposition step). Specifically, the other-side surface in the thickness direction (of the first sealable resin sheet 1) of the sealable multi-layer resin sheet 11 is brought into contact with the one-side surfaces in the thickness direction of the electronic elements 21.

[0134]

Next, as illustrated in FIG. 1C, the sealable multi-layer resin sheet 11 and the element mounting board 24 are pressed (sealing step). Preferably, the sealable multi-layer resin sheet 11 and element mounting board 24 are heat-pressed.

[0135]

For example, a press 27 having two flat plates presses the sealable multi-layer resin sheet 11 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.

[0136]

When the sealable multi-layer resin sheet 11 is pressed, the first 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 first 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.

[0137]

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

[0138]

In this manner, the first 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.

[0139]

On the other hand, the second sealable resin sheet 12 does not contain 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.

[0140]

The conditions for the press (for example, pressure, time, and temperature) are not especially limited. The conditions allowing the first 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 first 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.

[0141]

Specifically, the lower limit of the pressure of the press is, for example, 0.01 MPa, preferably, 0.05 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.

[0142]

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.

[0143]

In this manner, a sealing body 31 sealing the electronic elements 21 is formed (produced) from the sealable multi-layer resin sheet 11. A one-side surface in the thickness direction of the sealing body 31 is a flat surface.

[0144]

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 of the electronic element 21 (see FIG. 3C).

[0145]

Specifically, the upper limit of the sealing body entering length X can appropriately be set depending on the desired upper limit value of a cured product entering length Y. Specifically, for example, the upper limit of the sealing body entering length X may be 50 μm , preferably, 30 μm . It is important that the lower limit of the sealing body entering length X is, for example, -15 μm .

[0146]

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).

[0147]

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.

[0148]

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.

[0149]

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.

[0150]

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. Although described in detail below, the content ratio (B) of the first inorganic filling material to the first sealable resin sheet 1 and the content ratio (A) of the second inorganic filling material to the second sealable resin sheet 12 have a predetermined ratio and a predetermined relationship, and thus the degree of the entry of the cured product 41 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 of the electronic elements 21.

[0151]

When the chip is used for a SAW filter, the upper limit of the cured product entering length Y can appropriately be set in a range in which the cured product does not contact the wires on the rear surface of the chip. Specifically, the upper limit of the cured product entering length Y may be, for example, 30 μm , preferably, 25 μm . It is important that the lower limit of the cured product entering length Y is, for example, -10 μm .

[0152]

In the sealable multi-layer resin sheet 11, the content ratio (B) of the first inorganic filling material to the first sealable resin sheet 1 and the content ratio (A) of the second inorganic filling material to the second sealable resin sheet 12 have a predetermined ratio and a predetermined relationship. Thus, the entering amount of the cured product 41 that enters the gap 26 between the electronic element 21 and board 22 can be reduced when the cured product 41 as illustrated in FIG. 1D is formed by disposing the sealable multi-layer resin sheet 11 on the electronic elements 21 and heating the sealable multi-layer resin sheet 11 (sealing body 31).

[0153]

In detail, the lower limit of the content ratio (B) of the first inorganic filling material to the first material is, 50 mass%, preferably, 52 mass%, more preferably, 55 mass%, even more preferably, 57 mass%, particularly preferably, 60 mass%, most preferably, 62 mass%. The upper limit of the content ratio (B) of the first inorganic filling material to the first material is, for example, 80 mass%, preferably, 75 mass%, more preferably, 72 mass%, even more preferably, 70 mass%, particularly preferably, 68 mass%.

[0154]

When the content ratio (B) of the first inorganic filling material to the first material is the above-described lower limit or more, the sealable resin sheet 1 can flow in the step illustrated in FIG. 1C.

[0155]

The lower limit of the content ratio (A) of the second inorganic filling material to the second material is 60 mass%, preferably, 65 mass%, more preferably, 70 mass%, even more preferably, mass%, particularly preferably, 82 mass%. The upper limit of the content ratio (A) of the second inorganic filling material to the second material is, for example, 95 mass%, preferably 90 mass%, more preferably, 87 mass%, even more preferably, 86 mass%.

[0156]

When the content ratio (A) of the second inorganic filling material to the second material is the above-described lower limit or more, the second sealable resin sheet 12 can flow in the step illustrated in FIG. 1C.

[0157]

The content ratio (B) of the first inorganic filling material to the first sealable resin sheet 1 and the content ratio (A) of the second inorganic filling material to the second sealable resin sheet 12 satisfy the following formula (1).

[0158]

$$0.4A + 1.7B < 160 \quad (1)$$

As described above, the content ratio (B) of the first inorganic filling material to the first sealable resin sheet 1 and the content ratio (A) of the second inorganic filling material to the second sealable resin sheet 12 has a predetermined ratio and a predetermined relationship. This means that the lower limit of the content ratio (B) of the above-described first inorganic filling material is the above-described lower limit or more, the lower limit of the content ratio (A) of the above-described second inorganic filling material is the above-described lower limit or more, and the content ratio (B) of the above-described first inorganic filling material and the content ratio (A) of the above-described second inorganic filling material satisfy the above-described formula (1). Specifically, the content ratio (B) of the first inorganic filling material to the first sealable resin sheet 1 and the content ratio (A) of the second inorganic filling material to the second sealable resin sheet 12 are in a range of the shadowed area of FIG. 2.

[0159]

When the content ratio (B) of the first inorganic filling material to the first sealable resin sheet 1 and the content ratio (A) of the second inorganic filling material to the second sealable resin sheet 12 are in the above-described range, the entering amount of the cured product 41 that enters the gap 26 between the electronic element 21 and board 22 can be reduced when the cured product 41 is formed. Further, the entering amount of the cured product between the electronic element 21 and board 22 can be controlled as an appropriate value.

[0160]

On the other hand, when the content ratio (B) of the first inorganic filling material to the first material is less than the above-described lower limit (for details, a region A of FIG. 2), the reliability decreases.

[0161]

When the lower limit of the content ratio (A) of the second inorganic filling material to the second material is less than the above-described lower limit (for details, a region B of FIG. 2), the reliability decreases.

[0162]

When the content ratio (B) of the first inorganic filling material to the first sealable resin sheet 1 and the content ratio (A) of the second inorganic filling material 12 to the second sealable resin sheet 12 satisfy the following formula (2) (for details, a region C of FIG. 2), the forming properties of the first sealable resin sheet 1 and second sealable resin sheet 12 decrease.

[0163]

$$0.4A + 1.7B \geq 160 \quad (2)$$

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. 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 second sealable resin sheet 12 can be flattened in the step illustrated in FIG. 1C.

[0164]

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.

[0165]

In the step illustrated in FIG. 1C, 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. 1C, 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. 1C, the sealable resin sheet 1 is allowed to slightly enter the gap 26.

[0166]

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.

[0167]

The first sealable resin sheet 1 and/or the second sealable resin sheet 12 in the sealable multi-layer resin sheet 11 can have a plurality of layers.

[0168]

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.

[0169]

As an example of the element, the electronic elements 21 are described. However, a semiconductor element can be used as well. Specific examples of the electronic element include a surface acoustic wave filter (SAW filter).

Examples

[0170]

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").

[0171]

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

[0172]

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

Epoxy resin 1: 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)

Epoxy resin 2: JER 630 manufactured by Mitsubishi Chemical Corporation (triglycidyl amino phenol (glycidyl amine-type epoxy resin)), epoxy equivalent of 90 to 105 g/eq., liquid

Phenol resin 1: 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)

Phenol resin 2: TPM- 100 manufactured by Gunei Chemical Industry Co., Ltd. (tris hydroxyphenylmethane-type novolak resin), hydroxyl group equivalent: 98 g/eq.

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, number of functional groups: 736, weight-average molecular weight: 1290000, glass-transition temperature (Tg): -13.9°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), 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.

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 of First Sealable Resin Sheet>

Preparation Examples 1 to 10

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 50 μm . The first sealable resin sheet 1 was in B stage.

<Preparation of Second Sealable Resin Sheet>

Preparation Examples 11 to 17

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 precursor for a second sealable resin sheet 12 with a thickness of 52.5 μm . Four second-sealable-resin-sheet 12 precursors are laminated to form a second sealable resin sheet 12 with a thickness of 210 μm . The second sealable resin sheet 12 was in B stage.

[0173]

Examples 1 to 33 and Comparative Examples 1 to 23

In each of the combinations of Preparation Examples shown in Table 3, the second sealable resin sheet 12 is disposed on the one-side surface in the thickness direction of the first sealable resin sheet 1, thereby producing a sealable multi-layer resin sheet 11 with a thickness of 260 μm .

[0174]

Comparative Examples 22 and 23 showed low reliability and were inadequate to use in terms of the properties other than the entering amount.

[0175]

Evaluation

<Measurement of Cured Product Entering Length>

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

[0176]

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.

[0177]

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.

[0178]

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.

[0179]

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.

[0180]

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 was measured based on the side edge of the dummy element 71.

[0181]

The obtained cured product entering lengths Y are shown in Table 3.

[0182]

In the evaluation, the “minus” means that a space protruding outward from the side edge of the dummy element 71 was formed (see the thick dashed line in FIG. 1D). The absolute value of the “minus” corresponds to a length of the protruding space.

[0183]

<Measurement of Glass-transition Temperature>

The glass-transition temperatures of the first sealable resin sheet 1 and second sealable resin sheet 12 of each of Examples and Comparative Examples were measured by the local maximal value of the loss tangent ($\tan \delta$) measured using a dynamic viscoelastic measurement analyzer (DMA, frequency of 1 Hz, tensile mode, a rate of increase in temperature of 10°C/min). The results are shown in Table 3.

[0184]

<Measurement of Coefficient of Linear Expansion>

The coefficients of linear expansion of the first sealable resin sheet 1 and second sealable resin sheet 12 of each of Examples and Comparative Examples were measured using a thermomechanical measurement analyzer (TMA) under the following conditions. The results are shown in Table 3.

(Measurement Conditions)

Thermomechanical Measurement Analyzer (TMA): TMA (manufactured by TA Instruments Japan

Sample size: 4.5 mm × 20 mm

Mode: tensile mode

Rate of increase in temperature: 5°C/min

Measurement temperature range: 25 to 260°C

Observation

FIG. 4 illustrates a graph showing the relationship between the content ratio (B) of the first inorganic filling material to the first material and the content ratio (A) of the second inorganic filling material to the second material of each of Examples 1 to 33 and Comparative Examples 1 to 23.

[0185]

From the graph, relational expressions of FIG. 4 ($B \geq 50$, $A \geq 60$, and $0.4A + 1.7B < 160$) determine the range (shadowed part of FIG. 4) of the content ratio (B) of the first inorganic filling material and content ratio (A) of the second inorganic filling material to the second material, in which the cured product entering length can be reduced.

[0186]

In detail, Examples 1 to 33 included in the above-described range provided electronic element packages formed with appropriate cured product entering lengths, respectively, in comparison with Comparative Examples 1 to 23 excluded from the above-described range.

[0187]

[Table 1]

Preparation Example No.			Preparation Example 1	Preparation Example 2	Preparation Example 3	Preparation Example 4	Preparation Example 5	Preparation Example 6	Preparation Example 7	Preparation Example 8	Preparation Example 9	Preparation Example 10
Layered silicate compound	First inorganic filling material	Organic bentonite (modified by dimethyl distearyl ammonium)	S-BEN NX	(part(s))	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
		Silica	FB-8SM	(part(s))	21.45	23.60	25.74	27.89	30.03	32.18	34.32	35.18
	Second filler	Silica	SC220G-SMJ	(part(s))	11.55	12.71	13.86	15.02	16.17	17.33	18.48	18.94
Thermosetting resin			Epoxy resin 1	(part(s))	16.03	14.18	12.33	10.48	8.63	6.78	4.93	4.19
			Epoxy resin 2	(part(s))	-	-	-	-	-	-	-	-
			Phenol resin 1	(part(s))	1.66	1.47	1.28	1.09	0.90	0.70	0.51	0.43
			Phenol resin 2	(part(s))	6.66	5.89	5.12	4.35	3.58	2.81	2.05	1.74
Thermoplastic resin		20% acrylic polymer containing	HME-2006M	(part(s))	20.38	18.12	15.85	13.59	11.32	9.06	6.79	5.89
Silane coupling agent		Glycidyl group-containing	KBM-403	(part(s))	0.50	0.54	0.59	0.64	0.69	0.74	0.79	0.81
Curing accelerator		Imidazole series	2PHZ-PW	(part(s))	0.20	0.18	0.16	0.14	0.11	0.09	0.07	0.06
Solvent		Organic solvent	MEK	(part(s))	17.69	19.5	21.32	23.13	24.94	26.75	28.56	29.29
Pigment		Carbon black	#20	(part(s))	0.58	0.51	0.45	0.39	0.32	0.26	0.19	0.17
Content ratio (B) of first inorganic filling material to first sealable resin sheet				(mass%)	50	55	60	65	70	75	80	82
Thickness				(μm)	50	50	50	50	50	50	50	50

[0188]

[Table 2]

Preparation Example No.				Preparation Example 11	Preparation Example 12	Preparation Example 13	Preparation Example 14	Preparation Example 15	Preparation Example 16	Preparation Example 17
Layered silicate compound	Organic bentonite (modified by dimethyl distearyl ammonium)	S-BEN NX	(part(s))	-	-	-	-	-	-	-
	First filler	FB-8SM	(part(s))	34.32	40.04	45.76	47.48	48.62	49.76	31.46
Second inorganic filling material	Silica	SC220G-SMJ	(part(s))	18.48	21.56	24.64	25.56	26.18	26.80	16.94
Thermosetting resin	Epoxy resin 1	YSLV-80XY	(part(s))	8.78	6.49	4.21	3.52	3.06	2.61	9.92
	Epoxy resin 2	JER630	(part(s))	8.78	6.49	4.21	3.52	3.06	2.61	9.92
	Phenol resin 1	LVR-8210DL	(part(s))	14.38	10.64	6.9	5.77	5.02	4.27	16.26
	Phenol resin 2	TPM-100	(part(s))	0	0	0	0	0	0	0
Thermoplastic resin	20% acrylic polymer containing	HME-2006M	(part(s))	8.83	6.47	4.31	3.67	3.24	2.8	9.71
Silane coupling agent	Glycidyl group-containing	KBM-403	(part(s))	0.79	0.92	1.06	1.1	1.12	1.15	0.73
Curing accelerator	Imidazole series	2PHZ-PW	(part(s))	0.06	0.05	0.03	0.03	0.02	0.02	0.06
Solvent	Organic solvent	MEK	(part(s))	5.1	6.82	8.55	9.07	9.41	9.76	4.23
Pigment	Carbon black	#20	(part(s))	0.69	0.51	0.34	0.29	0.26	0.22	0.77
Content ratio (A) of second inorganic filling material to second sealable resin sheet			(mass%)	60	70	80	83	85	87	55
Thickness			(μm)	52.5	52.5	52.5	52.5	52.5	52.5	52.5

[Table 3]

Second sealable resin sheet	136	15	87	Preparation Ex.16	-	Example 29 (Y:4μm)	Example 30 (Y:1μm)	Example 31 (Y:3μm)	Example 32 (Y:3μm)	Example 33 (Y:10μm)	Comp. Ex. 18 (Y:17μm)	Comp. Ex. 19 (Y:32μm)	Comp. Ex. 20 (Y:243μm)	Comp. Ex. 21 (Y: unmeasurable)
	137	15	85	Preparation Ex.15	-	Example 24 (Y:6μm)	Example 25 (Y:1μm)	Example 26 (Y:5μm)	Example 27 (Y:0μm)	Example 28 (Y:7μm)	Comp. Ex. 14 (Y:11μm)	Comp. Ex. 15 (Y:25μm)	Comp. Ex. 16 (Y:198μm)	Comp. Ex. 17 (Y: unmeasurable)
	145	14	83	Preparation Ex.14	-	Example 19 (Y:18μm)	Example 20 (Y:23μm)	Example 21 (Y:14μm)	Example 22 (Y:9μm)	Example 23 (Y:3μm)	Comp. Ex. 10 (Y:14μm)	Comp. Ex. 11 (Y:30μm)	Comp. Ex. 12 (Y:176μm)	Comp. Ex. 13 (Y: unmeasurable)
	135	14	80	Preparation Ex.13	Comp. Ex. 23 (Y:25μm)	Example 13 (Y:19μm)	Example 14 (Y:14μm)	Example 15 (Y:4μm)	Example 16 (Y:2μm)	Example 17 (Y:9μm)	Comp. Ex. 7 (Y:41μm)	Comp. Ex. 8 (Y:142μm)	Comp. Ex. 9 (Y: unmeasurable)	
	143	32	70	Preparation Ex.12	-	Example 7 (Y:18μm)	Example 8 (Y:13μm)	Example 9 (Y:13μm)	Example 10 (Y:4μm)	Example 11 (Y:13μm)	Comp. Ex. 4 (Y:37μm)	Comp. Ex. 5 (Y:106μm)	Comp. Ex. 6 (Y: unmeasurable)	
	139	37	60	Preparation Ex.11	-	Example 1 (Y:22μm)	Example 2 (Y:17μm)	Example 3 (Y:11μm)	Example 4 (Y:4μm)	Example 5 (Y:14μm)	Comp. Ex. 1 (Y:35μm)	Comp. Ex. 2 (Y:103μm)	Comp. Ex. 3 (Y: unmeasurable)	
	141	52	55	Preparation Ex.17	-	-	-	-	Comp. Ex. 22 (Y:12μm)	-	-	-	-	-
	Glass-transition temperature (°C)	Coefficient of linear expansion (ppm/°C)	Content ratio (A) of second inorganic filling material to second sealable resin sheet	Preparation Ex.No.	Preparation Ex.10	Preparation Ex.1	Preparation Ex.2	Preparation Ex.3	Preparation Ex.4	Preparation Ex.5	Preparation Ex.6	Preparation Ex.7	Preparation Ex.8	Preparation Ex.9
				Content ratio (A) of second inorganic filling material to second sealable resin sheet	45	50	55	60	65	70	75	80	82	85
				Coefficient of linear expansion (ppm/°C)	86	80	73	63	58	34	26	25	19	14
				Glass-transition temperature (°C)	153	152	152	154	153	150	148	144	143	138
First sealable resin sheet														

[0190]

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

[0191]

The sealable multi-layer resin sheet is used to seal an element.

Description of Reference Numerals

[0192]

- 1 first sealable resin sheet
- 11 sealable multi-layer resin sheet
- 12 second sealable resin sheet

Claims

1. A sealable multi-layer resin sheet comprising: a first sealable resin sheet; and a second sealable resin sheet sequentially toward one side in a thickness direction, wherein

the first sealable resin sheet contains a layered silicate compound and a first inorganic filling material,

the second sealable resin sheet does not contain a layered silicate compound, and contains a second inorganic filling material,

a content ratio (B) of the first inorganic filling material to the first sealable resin sheet is 50 mass% or more,

a content ratio (A) of the second inorganic filling material to the second sealable resin sheet is 60 mass% or more, and

the content ratio (B) of the first inorganic filling material to the first sealable resin sheet and the content ratio (A) of the second inorganic filling material to the second sealable resin sheet satisfy a formula (1) described below.

$$0.4A + 1.7B < 160 \quad (1)$$

2. The sealable multi-layer resin sheet according to Claim 1, wherein

the first sealable resin sheet has a thickness of 30 μm or more and 100 μm or less, and

the second sealable resin sheet has a thickness of 50 μm or more and 500 μm or less.

3. The sealable multi-layer resin sheet according to Claim 1, wherein

the first sealable resin sheet has a coefficient of linear expansion of 80 ppm/ $^{\circ}\text{C}$ or less, and

the second sealable resin sheet has a coefficient of linear expansion of 50 ppm/ $^{\circ}\text{C}$ or less.