

TITLE OF THE INVENTION

SEALABLE SHEET

BACKGROUND OF THE INVENTION

Field of the Invention

[0001]

The present invention relates to a sealable sheet, to be specific, to a sealable sheet for sealing an electronic element.

Description of Related Art

[0002]

Conventionally, it has been known that an electronic element is sealed by a sealable sheet.

[0003]

As the sealable sheet, for example, a resin sheet in which an outermost layer and an innermost layer each containing a thermosetting component are included has been proposed (ref: for example, following Patent Document 1).

[0004]

The resin sheet described in Patent Document 1 is disposed in the electronic element, thereafter, embeds the electronic element by thermal pressing, and subsequently, the resin sheet is thermally cured to form a sealing body (cured sheet).

Citation List

Patent Document

[0005]

Patent Document 1: Japanese Unexamined Patent Publication No. 2018-103584

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0006]

However, the sealing body (cured sheet) described in Patent Document 1 may be peeled from the electronic element when repeatedly heated at high temperature.

[0007]

The resin sheet is required to suppress the production of warping in the sealing body after curing and at the time of cooling of the sealing body at high temperature.

[0008]

The present invention provides a sealable sheet having excellent heat resistance after sealing an electronic element and capable of suppressing warping.

MEANS FOR SOLVING THE PROBLEM

[0009]

The present invention (1) includes a sealable sheet for sealing an electronic element including a first layer in contact with the electronic element when sealing the electronic element and a second layer exposed outwardly sequentially toward one side in a thickness direction, wherein the first layer and the second layer have thermosetting properties, a glass transition temperature Tg1 of the first layer after curing is 150°C or more, and a glass transition temperature Tg2 of the second layer after curing is 80°C or less.

[0010]

The present invention (2) includes the sealable sheet described in (1), wherein the first layer contains an inorganic filler at a ratio of above 70 mass% and the second layer contains an inorganic filler at a ratio of 70 mass% or less.

[0011]

The present invention (3) includes the sealable sheet described in (2), wherein a difference between a ratio of the inorganic filler in the first layer and a ratio of the inorganic filler in the second layer is 50 mass% or less.

EFFECT OF THE INVENTION

[0012]

In the sealable sheet of the present invention, after sealing the electronic element to be cured, the glass transition temperature Tg1 of the first layer after curing is high of 150°C or more, so that the heat resistance is excellent.

[0013]

The glass transition temperature Tg1 of the first layer after curing is higher than the above-described glass transition temperature Tg2 of the second layer after curing, so that in a process of decreasing the temperature of the sealable sheet after curing by heating at high temperature of the glass transition temperature Tg1 or more of the first layer so as to reach normal temperature, when the temperature of the sealable sheet after curing is brought into the glass transition temperature Tg1 of the first layer after curing, the first layer after curing is in a glass state, and the second layer after curing is still in a rubber state. When the above-described cooling process is furthermore processed, and the temperature of the sealable sheet after curing is brought into the glass transition temperature Tg2 of the second layer after curing, the second layer after curing is in a glass state. Thereafter, the above-described process is furthermore processed, and both of the first layer and the second layer after curing in a glass state reach the

normal temperature.

[0014]

In a temperature range from the glass transition temperature Tg2 of the second layer after curing to the normal temperature, both of the first layer and the second layer after curing are hard (their states are common), and when a linear expansion coefficient of the first layer after curing is different from that of the second layer after curing, warping can be easily produced in the sealable sheet after curing caused by the difference.

[0015]

However, in the sealable sheet of the present invention, the glass transition temperature Tg2 of the second layer after curing is low of 80°C or less. Thus, the temperature range from the glass transition temperature Tg2 of the second layer after curing to the normal temperature is narrow. Thus, even when the linear expansion coefficient of the first layer after curing is different from that of the second layer after curing, the above-described warping can be suppressed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

FIGS. 1A to 1B show views for illustrating a one embodiment of a sealable sheet of the present invention and a producing method thereof:

FIG. 1A illustrating a cross-sectional view of the sealable sheet and

FIG. 1B illustrating a view of preparing a first layer and a second layer.

FIGS. 2A to 2B show views for illustrating a method for sealing an electronic element by using the sealable sheet shown in FIG. 1A:

FIG. 2A illustrating a step of preparing the electronic element and the sealable sheet and

FIG. 2B illustrating a step of sealing the electronic element by the sealable sheet.

DESCRIPTION OF EMBODIMENTS

[0017]

A one embodiment of a sealable sheet of the present invention is described with reference to FIGS. 1A to 2B.

[0018]

A sealable sheet 1 shown in FIG. 1A is an electronic element sealable sheet for sealing an electronic element 21 shown in FIG. 2A to produce an electronic element sealing package 30 shown in FIG. 2B. The sealable sheet 1 is not the electronic element sealing package 30 (ref: FIG. 2B) and is not a sealing layer 20 (ref: FIG. 2B) after sealing the electronic element 21. The

sealable sheet 1 is a precursor (before complete curing) sheet for forming the sealing layer 20 that is one component of the electronic element sealing package 30, does not include the electronic element 21, and to be specific, is an industrially available device whose component alone is circulated.

[0019]

As shown in FIG. 1A, the sealable sheet 1 has a generally plate shape (film shape) extending in a plane direction perpendicular to a thickness direction. The sealable sheet 1 has a one-side surface and an other-side surface that are spaced apart from each other in the thickness direction.

[0020]

The sealable sheet 1 sequentially includes, for example, a first layer 2 and a second layer 3 toward one side in the thickness direction. To be specific, the sealable sheet 1 includes the first layer 2 and the second layer 3 that is disposed on the one-side surface in the thickness direction of the first layer 2. The sealable sheet 1 preferably includes only the first layer 2 and the second layer 3.

[0021]

The first layer 2 forms the other-side surface in the thickness direction of the sealable sheet 1. The first layer 2 has a generally plate shape extending in the plane direction. The first layer 2 has the one-side surface and the other-side surface that are spaced apart from each other in the thickness direction.

[0022]

Although described later, the first layer 2 is also a contact layer that is in contact with a one-side surface 23 and peripheral side surfaces 25 (described later) in the thickness direction of the electronic element 21 and a one-side surface 26 in the thickness direction of a board 22 around the electronic element 21 when the sealable sheet 1 seals the electronic element 21 (ref: FIGS. 2A to 2B).

[0023]

The first layer 2 is a heat resistance-improving layer that is in tight contact (contact) with the electronic element 21 and is also in tight contact (contact) with the board 22 that is mounted with the electronic element 21 when the sealable sheet 1 seals the electronic element 21, and suppresses peeling of the sealing layer 20 from the electronic element 21 and/or the board 22 and suppresses damage (crack) of the sealing layer 20 when the sealing layer 20 is repeatedly heated.

[0024]

The first layer 2 is constituted to be deformed corresponding to the shape of the electronic element 21 when the sealable sheet 1 seals the electronic element 21.

[0025]

The first layer 2 has thermosetting properties.

[0026]

A material for the first layer 2 is not particularly limited as long as a glass transition temperature Tg1 (described later) of the first layer 2 after curing is within a desired range. An example of the material for the first layer 2 includes a first sealing composition containing a thermosetting component.

[0027]

The thermosetting component is a component that is once softened by heating at the time of sealing of the electronic element 21, and furthermore, is melted and flows to be cured by further heating.

[0028]

The thermosetting component is, for example, in a B-stage state and not in a C-stage state (that is, a state before complete curing) in the first layer 2. The B-stage is a state between an A-stage state in which the thermosetting component is liquid and a C-stage state in which the thermosetting component is completely cured, and is a state in which the curing is slightly processed, and a compressive elastic modulus of the thermosetting component is smaller than that of the thermosetting component in a C-stage state.

[0029]

The thermosetting component contains, for example, a main agent, a curing agent, and a curing accelerator.

[0030]

Examples of the main agent include epoxy resin, phenol resin, melamine resin, vinyl ester resin, cyanoester resin, maleimide resin, and silicone resin. As the main agent, in view of heat resistance or the like, preferably, an epoxy resin is used. When the main agent is the epoxy resin, the thermosetting component constitutes an epoxy thermosetting component along with the curing agent (epoxy curing agent) and the curing accelerator (epoxy curing accelerator) to be described later.

[0031]

Examples of the epoxy resin 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.

[0032]

Preferably, a combination of a bifunctional epoxy resin and a multifunctional epoxy resin is used, more preferably, a combination of a bisphenol A epoxy resin and a trishydroxyphenyl methane epoxy resin is used.

[0033]

A state of the epoxy resin at 25°C may be any one of liquid, solid, or semi-solid. Preferably, a combination of liquid and solid at 25°C is used, more preferably, semi-solid at 25°C is used alone.

[0034]

A ratio of the main agent (preferably, an epoxy resin) in the first sealing composition is, for example, 1 mass% or more, preferably 2.5 mass% or more, more preferably 4 mass% or more, and for example, 30 mass% or less, preferably 10 mass% or less, more preferably 5 mass% or less. The ratio of the main agent (preferably, an epoxy resin) in the thermosetting component is, for example, 30 mass% or more, preferably 40 mass% or more, and for example, 90 mass% or less, preferably 75 mass% or less.

[0035]

The curing agent is a component (preferably, an epoxy resin curing agent) that cures the above-described main agent by heating. Examples of the curing agent include phenol resins such as biphenylphenol novolak-type and triphenylmethane-type. Preferably, a triphenylmethane-type phenol resin is used. A mixing amount of the curing agent with respect to 100 parts by mass of the main agent is, for example, 30 parts by mass or more, preferably 40 parts by mass or more, and for example, 150 parts by mass or less, preferably 120 parts by mass or less.

[0036]

The curing accelerator is a catalyst (thermosetting catalyst) (preferably, epoxy resin curing accelerator) that promotes curing of the main agent by heating, and examples thereof include organic phosphorus compounds and imidazole compounds such as 2-phenyl-4-methyl-5-hydroxy methyl imidazole (2P4MHZ). Preferably, an imidazole compound is used. The mixing amount of the curing accelerator with respect to 100 parts by mass of the main agent is, for

example, 0.05 parts by mass or more, and for example, 5 parts by mass or less.

[0037]

Preferably, the first sealing composition further contains an inorganic filler.

[0038]

The inorganic filler is inorganic particles that improve deformation suppressive properties of a first sealing layer 6 after curing (described later). Examples of a material for the inorganic filler include inorganic compounds such as quartz glass, talc, silica, alumina, aluminum nitride, silicon nitride, and boron nitride. These can be used alone or in combination of two or more. Preferably, silica is used.

[0039]

A shape of the inorganic filler is not particularly limited, and examples of the shape thereof include generally sphere shape, generally plate shape, generally needle shape, and amorphous shape. Preferably, a generally sphere shape is used.

[0040]

An average value of the maximum length (in the case of a generally sphere shape, an average particle size) of the inorganic filler is, for example, 50 μm or less, preferably 20 μm or less, more preferably 10 μm or less, and for example, 0.1 μm or more, preferably 0.5 μm or more.

[0041]

The inorganic filler can include a first filler and a second filler having an average value of the maximum length that is smaller than the average value of the maximum length of the first filler.

[0042]

The average value of the maximum length (in the case of a generally sphere shape, an average particle size) of the first filler is, for example, 1 μm or more, preferably 3 μm or more, and for example, 50 μm or less, preferably 30 μm or less.

[0043]

The average value of the maximum length (in the case of a generally sphere shape, an average particle size) of the second filler is, for example, below 1 μm , preferably 0.8 μm or less, and for example, 0.01 μm or more, preferably 0.1 μm or more.

[0044]

The material for the first filler and that for the second filler may be the same or different from each other.

[0045]

Furthermore, the surface of the inorganic filler (the first filler and/or the second filler) may be partially or entirely subjected to surface treatment with a silane coupling agent or the like.

[0046]

The ratio of the inorganic filler in the first sealing composition (the first layer 2) is, for example, 60 mass% or more, preferably 70 mass% or more, more preferably above 70 mass%, further more preferably 75 mass% or more, particularly preferably 80 mass% or more, most preferably above 80 mass%, moreover 82.5 mass% or more. The ratio of the inorganic filler in the first sealing composition is, for example, 95 mass% or less, preferably 90 mass% or less.

[0047]

When the ratio of the inorganic filler in the first layer 2 is above the above-described lower limit, an increase of a first linear expansion coefficient α_1 of the first layer 2 is suppressed, in this manner, the warping of the sealing layer 20 can be effectively suppressed, and accordingly, the heat resistance of the sealing layer 20 can be improved.

[0048]

When the ratio of the inorganic filler in the first layer 2 is below the above-described upper limit, the handleability of the sealable sheet 1 can be excellent. Among all, when the ratio of the inorganic filler in the first layer 2 is above 90 mass%, there may be a case where the first layer 2 is too hard, so that it becomes fragile, and a package shape cannot be retained at the time of step flowing (at the time of handling).

[0049]

When the inorganic filler contains the first filler and the second filler, a content ratio of the first filler in the inorganic filler is, for example, above 50 mass%, preferably 60 mass% or more, and for example, 90 mass% or less, preferably 75 mass% or less. The content ratio of the second filler in the inorganic filler is a remaining portion of the description above.

[0050]

Furthermore, the first sealing composition can also contain, for example, additives such as thermoplastic resin, organic filler, silane coupling agent, and pigment.

[0051]

The thermoplastic resin is a component for improving the flexibility of the first layer 2 at the time of sealing of the electronic element 21. 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. As the thermoplastic resin, preferably, in view of improvement of the dispersibility with the main agent (preferably, an epoxy resin), an acrylic resin is used.

[0052]

An example of the acrylic resin includes a carboxyl group-containing (meth)acrylate copolymer (preferably, a 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).

[0053]

An example of the alkyl group includes 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.

[0054]

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

[0055]

A weight average molecular weight of the thermoplastic resin is, for example, 100,000 or more, preferably 500,000 or more, and for example, 1,000,000 or less, preferably 800,000 or less.

[0056]

The ratio (solid content ratio) of the thermoplastic resin in the first sealing composition is, for example, 0.1 mass% or more, preferably 0.5 mass% or more, and for example, 5 mass% or less, preferably 1 mass% or less. The thermoplastic resin may be prepared by being diluted with a solvent (methyl ethyl ketone or the like).

[0057]

The organic filler is not particularly limited, and examples thereof include polymer particles. Examples of a polymer that constitutes the polymer particles include silicone polymer (silicone rubber), acrylic polymer, epoxy polymer, and styrene polymer. Preferably, a silicone polymer is used. The shape of the polymer particles is not particularly limited, and examples of the shape thereof include generally sphere shape, generally plate shape, generally needle shape, and amorphous shape. Preferably, a generally sphere shape is used. The

average value of the maximum length (in the case of a generally sphere shape, an average particle size) of the polymer particles is, for example, 0.5 μm or more, and for example, 20 μm or less.

[0058]

The polymer particles can contain, for example, a functional group (preferably, an epoxy group) such as epoxy group, carboxyl group, and hydroxyl group on the surfaces thereof.

[0059]

The content ratio of the organic filler in the first sealing composition is, for example, 1 mass% or more, preferably 2 mass% or more, and for example, 8 mass% or less, preferably 5 mass% or less.

[0060]

An example of the silane coupling agent includes a silane coupling agent containing an epoxy group. Examples of the silane coupling agent containing an epoxy group include glycidoxy alkyl dialkyl dialkoxo silanes such as 3-glycidoxy propyl methyl dimethoxy silane and 3-glycidoxy propyl methyl diethoxy silane and glycidoxy alkyl trialkoxy silanes such as 3-glycidoxy propyl trimethoxy silane and 3-glycidoxy propyl triethoxy silane. Preferably, a glycidoxy alkyl trialkoxy silane is used. The content ratio of the silane coupling agent in the first sealing composition is, for example, 0.2 mass% or more, preferably 1 mass% or more, and for example, 5 mass% or less, preferably 2.5 mass% or less.

[0061]

An example of the pigment includes black pigment such as carbon black. The average particle size of the pigment is, for example, 0.001 μm or more and, for example, 1 μm or less. The ratio of the pigment in the first sealing composition is, for example, 0.1 mass% or more, preferably 0.25 mass% or more, and for example, 2 mass% or less, preferably 0.75 mass% or less.

[0062]

A thickness of the first layer 2 is a distance between the one-side surface and the other-side surface of the first layer 2, and is, for example, 10 μm or more, preferably 20 μm or more, more preferably 50 μm or more, and for example, 300 μm or less, preferably 200 μm or less, more preferably 100 μm or less.

[0063]

As described above, the first layer 2 has the thermosetting properties, so that it can be cured (completely cured, brought into a C-stage state) by heating.

[0064]

Next, the properties of the first layer 2 after curing are described.

[0065]

The glass transition temperature T_{g1} of the first layer 2 after curing is, for example, 150°C or more, preferably 155°C or more, more preferably 160°C or more, further more preferably 165°C or more, particularly preferably 170°C or more, most preferably 175°C or more. The glass transition temperature T_{g1} of the first layer 2 after curing is, for example, 230°C or less, preferably 210°C or less, more preferably 190°C or less.

[0066]

The glass transition temperature T_{g1} of the first layer 2 after curing is calculated as a peak value of $\tan\delta$ (E''/E') obtained by dynamic viscoelasticity measurement of a frequency of 1 Hz, a temperature rising rate of 10°C/min, a temperature range of 0 to 260°C, and a tensile mode. A glass transition temperature T_{g2} of the second layer 3 after curing to be described later is also measured in the same manner as that described above.

[0067]

When the glass transition temperature T_{g1} of the first layer 2 after curing is below the above-described lower limit, the heat resistance of the sealing layer 20 including the first layer 2 after curing (the first sealing layer 6) is reduced.

[0068]

A tensile storage elastic modulus $E'1$ at 260°C of the first layer 2 after curing is, for example, 0.05 GPa or more, preferably 0.1 GPa or more, more preferably 0.2 GPa or more, further more preferably 0.5 GPa or more, particularly preferably 0.75 GPa or more, and, for example, 10 GPa or less, preferably 5 GPa or less.

[0069]

The tensile storage elastic modulus $E'1$ of the first layer 2 after curing is also obtained in the measurement of the above-described glass transition temperature T_{g1} . A tensile storage elastic modulus $E'2$ of the second layer 3 after curing is measured in the same manner as that described above.

[0070]

When the tensile storage elastic modulus $E'1$ at 260°C of the first layer 2 after curing is the above-described lower limit or more, the warping of the sealable sheet 1 after curing (the sealing layer 20) can be suppressed, and accordingly, the heat resistance of the first layer 2 after curing is excellent.

[0071]

When the tensile storage elastic modulus $E'1$ at 260°C of the first layer 2 after curing is the above-described upper limit or less, the warping of the sealable sheet 1 after curing (the sealing layer 20) can be suppressed, and the sealing reliability is excellent.

[0072]

A first linear expansion coefficient $\alpha1$ of the first layer 2 after curing is, for example, 50 ppm or less, preferably 25 ppm or less, more preferably 20 ppm or less, further more preferably 10 ppm or less, particularly preferably 7 ppm or less, and for example, 0 ppm or more, preferably 1 ppm or more. The first linear expansion coefficient $\alpha1$ is a linear expansion coefficient at the glass transition temperature $Tg1$ or less.

[0073]

When the first linear expansion coefficient $\alpha1$ of the first layer 2 after curing is the above-described upper limit or less, the warping suppressive properties of the first layer 2 after curing can be improved, and accordingly, the heat resistance of the first layer 2 after curing is excellent.

[0074]

As shown in FIG. 1A, the second layer 3 forms the one-side surface in the thickness direction of the sealable sheet 1. The second layer 3 has a generally plate shape extending in the plane direction. The second layer 3 has the one-side surface and the other-side surface that are spaced apart from each other in the thickness direction.

[0075]

The second layer 3 is disposed on the entire one-side surface of the first layer 2. The other-side surface of the second layer 3 is in contact with the one-side surface of the first layer 2. The one-side surface of the second layer 3 is exposed toward one side in the thickness direction.

[0076]

As shown in FIGS. 2A to 2B, the second layer 3 is, for example, a non-contact layer that is not in contact with the electronic element 21 when the sealable sheet 1 seals the electronic element 21, and to be specific, the second layer 3 covers the electronic element 21 via the first layer 2.

[0077]

When the sealable sheet 1 seals the electronic element 21, the second layer 3 flexibly binds (suppresses excessive flowing of) the first layer 2 that is deformed corresponding to the electronic element 21, while supporting it. To be specific, in the second layer 3, when the

electronic element 21 is sealed, the other-side surface of the second layer 3 is deformed corresponding to the deformation of the first layer 2. Meanwhile, the one-side surface of the second layer 3 retains its flat (plane) shape.

[0078]

The second layer 3 is a warping suppressive layer (deformation suppressive layer) that is brought into high temperature at the time of sealing of the electronic element 21 by the sealable sheet 1 and/or curing of the sealable sheet 1 by the subsequent heating, and thereafter, suppresses the warping (deformation caused by cooling) of the sealable sheet 1 after curing (that is, the sealing layer 20) when the temperature of the sealable sheet 1 after curing is decreased.

[0079]

The second layer 3 has the thermosetting properties.

[0080]

The material for the second layer 3 is not particularly limited as long as the glass transition temperature Tg2 (described later) of the second layer 3 after curing is within a desired range. An example of the material for the second layer 3 includes a second sealing composition containing the thermosetting component.

[0081]

An example of the second sealing composition includes a component contained in the first sealing composition. The kind and the mixing ratio of each of the components are appropriately selected from the above-described range.

[0082]

As the epoxy resin (main agent of the thermosetting component) contained in the second sealing composition, preferably, a modified bisphenol A epoxy resin is used. The ratio of the main agent (preferably, an epoxy resin) in the first sealing composition is, for example, 5 mass% or more, preferably 15 mass% or more, more preferably 17.5 mass% or more, further more preferably 20 mass% or more, and for example, 50 mass% or less, preferably 35 mass% or less.

[0083]

As the phenol resin (curing agent of the thermosetting component) contained in the second sealing composition, preferably, a biphenylphenol novolak-type phenol resin is used.

[0084]

Preferably, the second sealing composition does not contain the organic filler.

[0085]

Preferably, the inorganic filler does not contain the second filler, and contains only the first

filler.

[0086]

The ratio of the inorganic filler (preferably, the first filler) in the second sealing composition (the second layer 3) is, for example, 80 mass% or less, preferably 70 mass% or less, more preferably below 70 mass%, further more preferably 65 mass% or less, and for example, 25 mass% or more, preferably 50 mass% or more.

[0087]

When the ratio of the inorganic filler in the second layer 3 is below the above-described upper limit, the warping caused by an excessive increase of the tensile storage elastic modulus E' to be described later can be suppressed. When the ratio of the inorganic filler in the second layer 3 is above the above-described lower limit, the excessive flowing of the second layer 3 after curing in the first layer 2 after curing can be suppressed. Among all, when the ratio of the inorganic filler in the second layer 3 is 50 mass% or more, the excessive flowing of the first layer 2 at the time of sealing can be suppressed, and unevenness of the thickness can be suppressed. Preferably, the ratio of the inorganic filler in the second sealing composition is lower than that of the inorganic filler in the first sealing composition. In this case, the heat resistance is improved by the first layer 2 after curing, and the second layer 3 after curing is flexible, so that the strength of binding the first layer 2 is weak, and the warping of the sealable sheet 1 after curing can be suppressed.

[0088]

Preferably, the ratio of the inorganic filler in the first sealing composition is above 70 mass%, and the ratio of the inorganic filler in the second sealing composition is 70 mass% or less.

[0089]

More preferably, the ratio of the inorganic filler in the first sealing composition is above 70 mass%, and the ratio of the inorganic filler in the second sealing composition is 65 mass% or less.

[0090]

The ratio (ratio of the inorganic filler in the first sealing composition/ratio of the inorganic filler in the second sealing composition) of the ratio of the inorganic filler in the first sealing composition with respect to the ratio of the inorganic filler in the second sealing composition is, for example, above 1, preferably 1.25 or more, and for example, 5 or less, preferably 2 or less, more preferably 1.75 or less. When the ratio is the above-described lower limit or more, the

second layer 3 after curing is flexible, so that the strength of binding the first layer 2 is weak, and the warping can be furthermore surely suppressed. When the ratio is the above-described upper limit or less, a difference of the viscosity between the first layer 2 and the second layer 3 can be reduced as much as possible, and thus, the unevenness of the thickness can be suppressed.

[0091]

The difference between the ratio of the inorganic filler in the first layer and that of the inorganic filler in the second layer (to be specific, a value obtained by subtracting the ratio of the inorganic filler in the second layer from the ratio of the inorganic filler in the first layer) is, for example, 60 mass% or less, preferably 50 mass% or less, more preferably 30 mass% or less. When the above-described difference is the above-described upper limit or less, the difference of the viscosity between the first layer 2 and the second layer 3 can be reduced as much as possible, and thus, the unevenness of the thickness can be suppressed.

[0092]

Meanwhile, the above-described difference is, for example, 1 mass% or more, preferably above 5 mass%, more preferably 10 mass% or more, further more preferably 20 mass% or more.

[0093]

Among all, when the above-described difference is 20 mass% or more, the heat resistance is retained by a large number of inorganic filler in the first layer 2, and the warping caused by the excessive increase of the tensile storage elastic modulus E' can be suppressed.

[0094]

As described above, the second layer 3 has the thermosetting properties, so that it can be cured (completely cured, brought into a C-stage state) by heating.

[0095]

Next, the properties of the second layer 3 after curing are described.

[0096]

The glass transition temperature Tg_2 of the second layer 3 after curing is lower than the above-described glass transition temperature Tg_1 of the first layer 2 after curing and to be specific, is 80°C or less. The glass transition temperature Tg_2 of the second layer 3 after curing is preferably 75°C or less, more preferably 70°C or less, further more preferably 65°C or less, particularly preferably 60°C or less, most preferably 55°C or less. The glass transition temperature Tg_2 of the second layer 3 after curing is, for example, 40°C or more, preferably 45°C or more.

[0097]

When the glass transition temperature Tg2 of the second layer 3 after curing is above the above-described upper limit, the warping of the sealing layer 20 including the second layer 3 after curing cannot be sufficiently suppressed.

[0098]

Also, the glass transition temperature Tg2 of the second layer 3 after curing is 80°C or less, so that the temperature range from the glass transition temperature Tg2 of the second layer 3 after curing to the normal temperature is narrow. Thus, even when the linear expansion coefficient of the first layer 2 after curing is different from that of the second layer 3 after curing, the warping can be suppressed.

[0099]

When the glass transition temperature Tg2 of the second layer 3 after curing is above the above-described lower limit, the shape retainability of the second layer 3 after curing can be secured.

[0100]

Among all, when the glass transition temperature Tg2 of the second layer 3 after curing is 40°C or less, the resin such as thermosetting component contained in the second sealing composition is excessively soft, so that the second layer 3 after curing cannot be subjected to dicing. Furthermore, picking up the second layer 3 after curing is difficult.

[0101]

Also, the temperature (difference in temperature) (Tg1 - Tg2) obtained by subtracting the glass transition temperature Tg2 of the second layer 3 after curing from the glass transition temperature Tg1 of the first layer 2 after curing is, for example, 70°C or more, preferably 90°C or more, more preferably 100°C or more, further more preferably 110°C or more, particularly preferably 120°C or more, and for example, 150°C or less, preferably 140°C or less. When the difference in temperature is within the above-described range, both of the heat resistance and the warping suppressive properties are excellent.

[0102]

The tensile storage elastic modulus E'2 at 260°C of the second layer 3 after curing is, for example, 1 GPa or less, preferably 0.3 GPa or less, more preferably 0.1 GPa or less, further more preferably 0.05 GPa or less, and for example, 0.001 GPa or more, preferably 0.005 GPa or more.

[0103]

When the tensile storage elastic modulus E'2 at 260°C of the second layer 3 is below the above-described upper limit, the warping of the sealable sheet 1 after curing (the sealing layer

20) can be more effectively suppressed.

[0104]

The ratio ($E'1/E'2$) of the tensile storage elastic modulus $E'1$ at 260°C of the first layer 2 after curing with respect to the tensile storage elastic modulus $E'2$ at 260°C of the second layer 3 after curing is, for example, 1.5 or more, preferably 10 or more, more preferably 30 or more, further more preferably 60 or more, particularly preferably 100 or more, and for example, 200 or less.

[0105]

When the above-described ratio of the tensile storage elastic modulus $E'2$ is the above-described lower limit or more, the second layer 3 after curing is flexible, so that the strength of binding the first layer 2 is weak, and the warping can be more surely suppressed.

[0106]

The first linear expansion coefficient $\alpha1$ of the second layer 3 after curing is, for example, 25 ppm or more, preferably 45 ppm or more, more preferably 55 ppm or more, further more preferably 75 ppm or more, and for example, 200 ppm or less, preferably 100 ppm or less. The first linear expansion coefficient $\alpha1$ is a linear expansion coefficient at the glass transition temperature $Tg2$ or less.

[0107]

The first linear expansion coefficient $\alpha1$ of the second layer 3 after curing is, for example, larger than the first linear expansion coefficient $\alpha1$ of the first layer 2 after curing, and to be specific, the difference therebetween is, for example, 10 ppm or more, preferably 20 ppm or more, more preferably 30 ppm or more, further more preferably 40 ppm or more, and for example, 200 ppm or less, preferably 100 ppm or less.

[0108]

The thickness of the second layer 3 is a distance between the one-side surface and the other-side surface of the second layer 3, and is, for example, 10 μm or more, preferably 20 μm or more, more preferably 50 μm or more, and for example, 300 μm or less, preferably 200 μm or less, more preferably 100 μm or less.

[0109]

The thickness of the sealable sheet 1 is a distance between the other-side surface of the first layer 2 and the one-side surface of the second layer 3, and is the total sum of the thickness of the first layer 2 and that of the second layer 3. The thickness of the sealable sheet 1 is, for example, 50 μm or more, preferably 100 μm or more, and for example, 2000 μm or less,

preferably 500 μm or less.

[0110]

To produce the sealable sheet 1, for example, as shown in FIG. 1B, first, the first layer 2 and the second layer 3 are formed, and thereafter, as shown in FIG. 1A, the first layer 2 is attached to the second layer 3.

[0111]

To form the first layer 2, first, the first sealing composition is prepared. To be specific, the above-described components are blended to be mixed, so that the first sealing composition in an A-stage state is prepared. Preferably, the above-described components (and a solvent as needed) are blended and mixed, so that a varnish is prepared. Thereafter, the varnish is applied to the surface of a first peeling sheet 4 shown by a phantom line to be dried by heating, so that the first layer 2 in a B-stage state is obtained. The first layer 2 can be also directly formed from the first sealing composition by kneading and extruding without preparing the varnish.

[0112]

To form the second layer 3, the second sealing composition is prepared. To be specific, the above-described components are blended to be mixed, so that the second sealing composition in an A-stage state is prepared. Preferably, the above-described components (and a solvent as needed) are blended and mixed, so that a varnish is prepared. Thereafter, the varnish is applied to the surface of a second peeling sheet 5 shown by the phantom line to be dried by heating, so that the second layer 3 in a B-stage state is obtained. The second layer 3 can be also directly formed from the second sealing composition by kneading and extruding without preparing the varnish.

[0113]

Of the first layer 2 and the second layer 3, one can be also directly formed (disposed) with respect to the other.

[0114]

Both of the first layer 2 and the second layer 3 have the thermosetting properties, so that preferably, the sealable sheet 1 is in a B-stage state.

[0115]

Next, a method for producing the electronic element sealing package 30 by sealing the electronic element 21 by the sealable sheet 1 is described with reference to FIGS. 2A to 2B.

[0116]

In this method, as shown in FIG. 2A, first, the sealable sheet 1 and the electronic element

21 are prepared.

[0117]

The sealable sheet 1 is prepared in accordance with the above-described producing method.

[0118]

The electronic element 21 is, for example, prepared in a state of being mounted on the board 22. The electronic element 21 and the board 22 constitute an element-mounted board 29. That is, the element-mounted board 29 includes the electronic element 21 and the board 22.

[0119]

The electronic element 21 has a generally flat plate shape extending in the plane direction. To be specific, the electronic element 21 integrally includes the one-side surface 23 and an other-side surface 24 that face each other in the thickness direction, and the peripheral side surfaces 25 that connect the peripheral end edges thereof. An electrode (not shown) is provided on the other-side surface 24 of the electronic element 21. The electronic element 21 is not particularly limited, and various electronic elements are used. Examples thereof include hollow electronic element and semiconductor element. The thickness of the electronic element 21 is, for example, 50 μm or more, and for example, 500 μm or less.

[0120]

The board 22 has a generally flat plate shape extending in the plane direction. The board 22 has the one-side surface 26 in the thickness direction facing the electronic element 21. A terminal (not shown) that is electrically connected to the electrode (not shown) of the electronic element 21 is provided on the one-side surface 26 of the board 22. Examples of the material for the board 22 include ceramics such as alumina and polymer such as polyimide. Preferably, in view of heat resistance, ceramics is used.

[0121]

Next, as shown in FIG. 2A, the sealable sheet 1 is disposed on the element-mounted board 29 so that the first layer 2 faces the electronic element 21.

[0122]

Subsequently, as shown by an arrow of FIG. 2A, and FIG. 2B, the sealable sheet 1 is thermally pressed toward the other side in the thickness direction by using, for example, a flat plate press (not shown) or the like. At this time, the sealable sheet 1 is plastically deformed corresponding to the outer shape of the electronic element 21.

[0123]

In this manner, the sealable sheet 1 is once softened to embed the electronic element 21. In other words, the electronic element 21 is embedded in the sealable sheet 1.

[0124]

The first layer 2 is deformed corresponding to the outer shape of the electronic element 21. The first layer 2 is in contact with the one-side surface 26 that is not overlapped with the electronic element 21 in the board 22 when projected in the thickness direction.

[0125]

Meanwhile, the other-side surface of the second layer 3 is deformed corresponding to the deformation of the first layer 2, and the one-side surface thereof retains its flat shape.

[0126]

Subsequently, the sealable sheet 1 in a B-stage state is thermally cured (brought into a C-stage state, completely cured) by heating, so that the sealing layer 20 is formed.

[0127]

As the heating conditions, for example, the conditions in which the thermosetting component contained in the first layer 2 and the second layer 3 can be completely cured (brought into a C-stage state) are used. To be specific, a heating temperature is, for example, 150°C or more, preferably 170°C or more, and for example, 200°C or less, preferably 180°C or less. The heating time is, for example, 0.5 hours or more, preferably 1 hour or more, and for example, 4 hours or less.

[0128]

The sealing layer 20 that is cured by heating includes the first sealing layer 6 that is obtained by curing the first layer 2, and a second sealing layer 7 that is obtained by curing the second layer 3. Preferably, the sealing layer 20 includes only the first sealing layer 6 and the second sealing layer 7.

[0129]

The first sealing layer 6 corresponds to the first layer 2 after curing, and has the same properties as those of the first layer 2 after curing described above.

[0130]

The second sealing layer 7 corresponds to the second layer 3 after curing, and has the same properties as those of the second layer 3 after curing described above.

[0131]

The sealing layer 20 after heating at high temperature is usually brought into the normal temperature (about 10 to 30°C) by cooling such as radiational cooling.

[0132]

In this manner, the electronic element sealing package 30 including the element-mounted board 29 and the sealing layer 20 is produced. The electronic element sealing package 30 preferably includes only the element-mounted board 29 and the sealing layer 20.

[0133]

In the sealable sheet 1, after sealing the electronic element 21 to be cured, the glass transition temperature $Tg1$ of the first layer 2 after curing (the first sealing layer 6) is high of 150°C or more, so that it has excellent heat resistance. That is, when the electronic element sealing package 30 is repeatedly heated at high temperature (for example, high temperature of 150°C or more), it has excellent heat resistance in which the sealing layer 20 is capable of continuing to seal the electronic element 21.

[0134]

The glass transition temperature $Tg1$ of the first layer 2 after curing (the first sealing layer 6) is higher than the above-described glass transition temperature $Tg2$ of the second layer 3 after curing (the second sealing layer 7), so that in a process of decreasing the temperature of the sealable sheet 1 after curing by heating at high temperature (for example, high temperature of 150°C or more) of the glass transition temperature $Tg1$ or more of the first layer 2 so as to reach the normal temperature, when the temperature of the sealable sheet 1 after curing is brought into the glass transition temperature $Tg1$ of the first layer 2 after curing, the first layer 2 after curing is in a glass state, and the second layer 3 after curing is still in a rubber state. When the above-described cooling process is furthermore processed, and the temperature of the sealable sheet 1 after curing is brought into the glass transition temperature $Tg2$ of the second layer 3 after curing, the second layer 3 after curing is in a glass state. That is, in the above-described cooling step of the sealable sheet 1 after curing, the state of the first layer 2 after curing and that of the second layer 3 after curing are sequentially changed from the rubber state to the glass state.

[0135]

Thereafter, the above-described process is furthermore processed, and both of the first layer 2 and the second layer 3 after curing that are brought into the glass state (that is, both of the states are common) reach the normal temperature.

[0136]

In the temperature range from the glass transition temperature $Tg2$ of the second layer 3 after curing to the normal temperature, both of the first layer 2 and the second layer 3 after

curing are hard, and when the first linear expansion coefficient α_1 of the first layer 2 after curing is different from that of the second layer 3 after curing, the first layer 2 and the second layer 3 after curing are in contact with each other, so that the warping can be easily produced in the sealable sheet 1 after curing caused by the difference.

[0137]

When the glass transition temperature Tg2 of the second layer 3 after curing is above 80°C (high), the temperature range from the glass transition temperature Tg2 of the second layer 3 after curing to the normal temperature (difference in temperature of those), that is, the state between the first layer 2 and the second layer 3 after curing is common, and the temperature range in which the warping is easily produced caused by the difference of the first linear expansion coefficient α_1 is widened. Thus, the above-described warping cannot be sufficiently suppressed.

[0138]

However, in the one embodiment, the glass transition temperature Tg2 of the second layer 3 after curing is low of 80°C or less, so that the temperature range of easily producing the warping is narrow. Thus, even when the first linear expansion coefficient α_1 of the first layer 2 after curing is different from that of the second layer 3 after curing, the above-described warping can be suppressed.

[0139]

In the above-described one embodiment, the element-mounted board 29 includes a single number of electronic element 21. Alternatively, though not shown, for example, the plurality of electronic elements 21 can be also included. In this manner, the same function and effect as that of the one embodiment can be achieved.

Examples

[0140]

Next, the present invention is further described based on Preparation Examples, Examples, and Comparative Examples below. The present invention is however not limited by the following Preparation Examples, Examples, and Comparative Examples. The specific numerical values in mixing ratio (content ratio), property value, and parameter used in the following description can be replaced with upper limit values (numerical values defined as “or less” or “below”) or lower limit values (numerical values defined as “or more” or “above”) of corresponding numerical values in mixing ratio (content ratio), property value, and parameter described in the above-described “DESCRIPTION OF EMBODIMENTS”.

[0141]

Each of the components used in Preparation Examples is shown in the following.

Acrylic resin: HME-2006M, manufactured by Negami Chemical Industrial Co., Ltd., carboxyl group-containing acrylate copolymer, weight average molecular weight: 600,000, methyl ethyl ketone solution having a concentration of solid content of 20 mass%

Epoxy resin A: EPICLON EXA-4850-150, manufactured by DIC Corporation, modified bisphenol A epoxy resin, liquid at 25°C

Epoxy resin B: jER828, manufactured by DIC Corporation, bisphenol A epoxy resin, liquid at 25°C

Epoxy resin C: EPPN501-HY, manufactured by Nippon Kayaku Co., Ltd., trishydroxyphenyl methane epoxy resin, solid at 25°C

Phenol resin A: MEH-7851SS, manufactured by Meiwa Plastic Industries, Ltd., biphenylphenol novolak phenol resin

Phenol resin B: TPM-100, manufactured by Gunei Chemical Industry Co., Ltd., triphenylmethane phenol resin

Curing accelerator: 2-phenyl-4-methyl-5-hydroxymethyl imidazole (2P4MHZ)

Organic filler: EP-2601, manufactured by Dow Corning Toray Co., Ltd., spherical silicone polymer particle having an epoxy group and having an average particle size of 2 μm

First filler: FB-5SDC, manufactured by Denka Company Limited, spherical silica powder (inorganic filler), average particle size of 5 μm

Second Filler: inorganic filler obtained by subjecting 100 parts by mass of SC220G-SMJ (average particle size of 0.5 μm) manufactured by Admatechs Company Limited to surface treatment with 1 part by mass of 3-methacryloxy propyl trimethoxy silane (trade name: KBM-503, manufactured by Shin-Etsu Chemical Co., Ltd.).

Silane coupling agent: KBM-403, manufactured by Shin-Etsu Chemical Co., Ltd., 3-glycidoxo propyl trimethoxy silane

Carbon black: #20, manufactured by Mitsubishi Chemical Corporation, black pigment

[0142]

Preparation Examples 1 to 5

(Preparation of Second Layer)

The second sealing composition was prepared in accordance with the mixing formulation described in Table 1, and subsequently, the second layer 3 having a thickness of 75 μm in a B-stage state was prepared from the second sealing composition.

[0143]

Preparation Examples 6 to 9

(Preparation of First Layer)

The first sealing composition was prepared in accordance with the mixing formulation described in Table 1, and subsequently, the first layer 2 having a thickness of 75 μm in a B-stage state was prepared from the first sealing composition.

[0144]

Evaluation of Properties after Curing in Preparation Examples 1 to 9

Each of the second layers 3 of Preparation Examples 1 to 5 was heated at 150°C for one hour to be cured (brought into a C-stage state). Thereafter, the following properties of each of the second layers 3 after curing were evaluated.

[0145]

Also, the following properties of each of the first layers 2 in Preparation Examples 6 to 9 were evaluated in the same manner as that of the second layer 3 after curing (being brought into a C-stage state).

[0146]

The results are shown in Table 1.

[0147]

<Tensile Storage Elastic Modulus E' and Glass Transition Temperature T_g >

After only the first layer 2 after curing was trimmed into a size of 0.1 cm in height and 5 cm in width, the dynamic viscoelasticity thereof was measured with the following measurement device and measurement conditions.

[0148]

Measurement device: solid viscoelasticity measurement device (type: RSA-G2, manufactured by TA Instruments)

Mode: tensile

Scanning temperature: 0 to 260°C

Frequency: 1 Hz

Temperature rising rate: 10°C/min

The tensile storage elastic modulus E' at 260°C of the first layer 2 after curing was obtained. Also, a curved line of $\tan\delta$ ($= E''/E'$) was obtained from the tensile storage elastic modulus E' and the tensile loss elastic modulus E'' , and the glass transition temperature T_{g1} was obtained as the peak value of $\tan\delta$.

[0149]

The tensile storage elastic modulus $E'2$ at 260°C of the second layer 3 after curing and the glass transition temperature $Tg2$ were also obtained in the same manner as that described above.

[0150]

<First Linear Expansion Coefficient>

After the first layer 2 after curing was trimmed into a size of 15 mm in height and 4.5 mm in width to be set in a tensile jig of a thermomechanical measurement device (manufactured by Rigaku Corporation, type: TMA 8310), the first linear expansion coefficient $\alpha1$ thereof was calculated.

[0151]

The measurement conditions are as follows.

[0152]

Temperature range: 25°C or more and glass transition temperature Tg or less

Tensile load: 2 g

Temperature rising rate: 5°C/min

The first linear expansion coefficient $\alpha1$ of the second layer 3 after curing was obtained in the same manner as that described above.

[0153]

Example 1 to Comparative Example 2

(Production of Sealable Sheet)

The first layer 2 and the second layer 3 described in Table 1 were attached to each other. In this manner, as shown in FIG. 1A, the sealable sheet 1 including the first layer 2 and the second layer 3 was produced. The properties or the like of the first layer 2 and the second layer 3 in the sealable sheet 1 were described in Tables 2 to 3.

[0154]

(Evaluation)

The following items were evaluated. The results are described in Tables 2 to 3.

[0155]

(Warping)

Each of the sealable sheets 1 of Example 1 to Comparative Example 2 was trimmed into a rectangular piece having 87 mm in height and 87 mm in width.

[0156]

Thereafter, the sealable sheet 1 was thermally pressed toward the central portion of the

surface of an alumina board (100 mm in height, 100 mm in width, 0.2 mm in thickness, the first linear expansion coefficient α_1 : 8 ppm) under the following attachment conditions, so that a sample was prepared.

[0157]

<Attachment Conditions>

Temperature: 95°C

Pressurizing time: 60 seconds

Pressurizing force: 300 kPa

Thereafter, the sample was heated at 170°C for two hours, so that the sealable sheet 1 was thermally cured (brought into a C-stage state). Thereafter, the sample was cooled until 25°C.

[0158]

Thereafter, an amount of warping of the sealable sheet 1 (amount of warping after curing) was measured at 25°C. To be specific, in the sample, a height of floating of the four corners of the sealable sheet 1 after curing from the surface of the alumina board was measured. Then, an average value of the height of the four corners (measurement value) was obtained as warping (amount of warping).

[0159]

The warping was evaluated based on the following criteria.

Excellent: warping was below 1 mm

Good: warping was 1 mm or more and below 1.5 mm

Bad: warping was 1.5 mm or more

[0160]

(Thermal Cycle Test)

Each of the sealable sheets 1 of Example 1 to Comparative Example 2 was trimmed into a circular piece having a diameter of 3 mm.

[0161]

Thereafter, the sealable sheet 1 was disposed and thermally pressed toward the central portion of the surface of the alumina board (100 mm in height, 100 mm in width, 0.2 mm in thickness) under the following attachment conditions, so that a sample was prepared.

[0162]

<Attachment Conditions>

Temperature: 95°C

Pressurizing time: 60 seconds

Pressurizing force: 300 kPa

Thereafter, the sample was heated at 150°C for one hour, so that the sealable sheet 1 was thermally cured (brought into a C-stage state). Thereafter, the sample was cooled until 25°C.

[0163]

Thereafter, the cooled sample was subjected to a thermal cycle test (temperature of -50°C to 125°C, one hour in one cycle, 1000 cycles), and the heat resistance was evaluated based on the following criteria.

[0164]

Excellent: after the thermal cycle test, either a crack in the sealable sheet 1 or peeling of the sealable sheet 1 from the alumina board did not occur.

[0165]

Good: after the thermal cycle test, the crack in the sealable sheet 1 or the peeling of the sealable sheet 1 from the alumina board occurred.

[0166]

Bad: after the thermal cycle test, both of the crack in the sealable sheet 1 and the peeling of the sealable sheet 1 from the alumina board occurred.

[0167]

(Unevenness of Thickness of Sealable Sheet after Curing)

The thickness in the plane direction of each of the sealable sheets 1 after curing (the sealing layers 20) of Examples 1 and 4 to 6 was measured, and the unevenness of the thickness was evaluated in accordance with the following criteria.

[0168]

Excellent: unevenness of thickness was below 5 μm

[0169]

Good: unevenness of thickness was 5 μm or more and below 10 μm

[0170]

Bad: unevenness of thickness was 10 μm or more

[0171]

[Table 1]

Table 1

Preparation Ex.		Second Layer						First Layer			
		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	
First/Second Sealing Composition	Acrylic Resin	388	388	237	679	388	255	332	723	388	
	Epoxy Resin A	2329	955	1421	4154	—	—	—	—	—	
	Epoxy Resin B	—	955	—	—	1618	325	290	1044	265	
	Epoxy Resin C	—	—	—	—	—	139	124	448	113	
	Phenol Resin A	1046	1465	638	1865	1757	—	—	—	—	
	Phenol Resin B	—	—	—	—	—	252	225	810	205	
	Curing Accelerator	0.27	0.27	0.17	0.48	0.27	0.08	0.08	0.22	0.08	
	Organic Filler	—	—	—	—	—	258	258	258	258	
	Inorganic Filler	First Filler	60.00	60.00	48.75	30.00	60.00	55.90	55.90	42.25	55.90
		Second Filler	—	—	26.25	—	—	30.10	30.10	22.75	30.10
	Content Ratio of Inorganic Filler	[mass%]	60.0	60.0	75.0	30.0	60.0	86.0	86.0	65.0	86.0
	Silane Coupling Agent	KBM-403	0.90	0.90	1.13	0.45	0.90	1.29	1.29	0.98	1.29
		Carbon Black	120	120	0.75	2.10	1.20	0.34	0.34	0.97	0.34
	Total Amount		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	Properties after Curing	Glass Transition Temperature T _g	tanδ	75	55	54	91	179	152	179	123
Tensile Storage Elastic Modulus E'		260°C	0.01	0.01	0.01	0.05	1.1	1.1	0.1	1.1	
First Linear Expansion Coefficient α ₁		T _g or less	75	79	48	132	41	6	8	32	10

[0172]

[Table 2]

Ex.: Comparative Ex.			Ex. 1	Ex. 2	Ex. 3	Ex. 4
First Layer			Preparation Ex. 6	Preparation Ex. 6	Preparation Ex. 7	Preparation Ex. 6
	Content Ratio of Inorganic Filler	[mass%]	86	86	86	86
	Glass Transition Temperature Tg1	[°C]	179	179	152	179
	Tensile Storage Elastic Modulus E'1 (260°C)	[GPa]	1.1	1.1	1.1	1.1
	First Thermal Expansion Coefficient α_1	[ppm]	6	6	8	6
Second Layer			Preparation Ex. 1	Preparation Ex. 2	Preparation Ex. 1	Preparation Ex. 3
	Content Ratio of Inorganic Filler	[mass%]	60	60	60	75
	Glass Transition Temperature Tg2	[°C]	55	75	55	55
	Tensile Storage Elastic Modulus E'2 (260°C)	[GPa]	0.01	0.01	0.01	0.5
	First Thermal Expansion Coefficient α_1	[ppm]	75	79	75	48
Comparison of Inorganic Filler	Content Ratio of Inorganic Filler in First Layer/Content Ratio of Inorganic Filler in Second Layer		1.4	1.4	1.4	1.1
	Content Ratio of Inorganic Filler in First Layer – Content Ratio of Inorganic Filler in Second Layer	[mass%]	26	26	26	11
Comparison of Properties after Curing	Tg1–Tg2	[°C]	124	104	97	124
	E'1/E'2		110	110	110	2.2
	First Thermal Expansion Coefficient α_1 of First Layer – First Thermal Expansion Coefficient α_1 of Second Layer		–69	–73	–67	–42
Evaluation of Sealable Sheet after Curing	Warping	[mm]	0.7	1.4	0.8	1.3
	Evaluation		Excellent	Good	Excellent	Good
	Thermal Cycle Test		Excellent	Excellent	Good	Excellent
	Unevenness of Thickness		Excellent	–	–	Excellent

[0173]

[Table 3]

Ex. Comparative Ex.			Ex. 5	Ex. 6	Comparative Ex. 1	Comparative Ex. 2
First Layer			Preparation Ex. 8	Preparation Ex. 6	Preparation Ex. 6	Preparation Ex. 9
	Content Ratio of Inorganic Filler	[mass%]	65	86	86	86
	Glass Transition Temperature Tg1	[°C]	179	179	179	123
	Tensile Storage Elastic Modulus E'1 (260°C)	[GPa]	0.1	1.1	1.1	1.1
	First Thermal Expansion Coefficient α_1	[ppm]	32	6	6	10
Second Layer			Preparation Ex. 1	Preparation Ex. 4	Preparation Ex. 5	Preparation Ex. 1
	Content Ratio of Inorganic Filler	[mass%]	60	30	60	60
	Glass Transition Temperature Tg2	[°C]	55	54	91	55
	Tensile Storage Elastic Modulus E'2 (260°C)	[GPa]	0.01	0.01	0.05	0.01
	First Thermal Expansion Coefficient α_1	[ppm]	75	132	41	75
Comparison of Inorganic Filler	Content Ratio of Inorganic Filler in First Layer/Content Ratio of Inorganic Filler in Second Layer		1.1	2.9	1.4	1.4
	Content Ratio of Inorganic Filler in First Layer – Content Ratio of Inorganic Filler in Second Layer	[mass%]	5	56	26	26
Comparison of Properties after Curing	Tg1–Tg2	[°C]	124	125	88	68
	E'1/E'2		10	110	22	110
	First Thermal Expansion Coefficient α_1 of First Layer – First Thermal Expansion Coefficient α_1 of Second Layer		–43	–126	–35	–65
Evaluation of Sealable Sheet after Curing	Warping	[mm]	1.4	0.3	1.8	0.8
	Evaluation		Good	Excellent	Bad	Excellent
	Thermal Cycle Test		Good	Excellent	Excellent	Bad
	Unevenness of Thickness		Excellent	Good	–	–

[0174]

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 the scope of the present invention. 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.

Description of Reference Numerals

[0175]

- 1 Sealable sheet
- 2 First layer
- 3 Second layer
- 21 Electronic element

WHAT IS CLAIMED IS:

1. A sealable sheet for sealing an electronic element comprising:
a first layer in contact with the electronic element when sealing the electronic element
and a second layer exposed outwardly sequentially toward one side in a thickness direction,
wherein
the first layer and the second layer have thermosetting properties,
a glass transition temperature Tg1 of the first layer after curing is 150°C or more, and
a glass transition temperature Tg2 of the second layer after curing is 80°C or less.
2. The sealable sheet according to claim 1, wherein
the first layer contains an inorganic filler at a ratio of above 70 mass% and
the second layer contains an inorganic filler at a ratio of 70 mass% or less.
3. The sealable sheet according to claim 2, wherein
a difference between a ratio of the inorganic filler in the first layer and a ratio of the
inorganic filler in the second layer is 50 mass% or less.