

SPECIFICATION

TITLE OF THE INVENTION

SEALABLE RESIN SHEET AND ELECTRONIC COMPONENT DEVICE

TECHNICAL FIELD

[0001]

The present invention relates to a sealable resin sheet and an electronic component device.

BACKGROUND ART

[0002]

An electronic component chip on a mounting substrate has sometimes been sealed with a sealable resin sheet. The sealable resin sheet is a sheet-shaped sealable resin material containing thermosetting resin.

[0003]

There is also a known electronic component chip mounted on a mounting substrate in a state of facing the substrate through a gap. The electronic component chip is sealed or encapsulated with a sealable resin sheet, for example, as follows.

[0004]

First, a sealable resin sheet with a predetermined thickness is pressed to electronic component chips on a mounting substrate by a plate pressing machine (pressing step), where the chips are bonded to the same surface of the substrate in a state of facing the substrate through a gap, and separated from each other. In this manner, the sealable resin sheet is softened by heating and plastic-deformed to cover each of the electronic component chips. Next, the sealable resin sheet covering the electronic component chips is cured by heating at a higher temperature (curing step). In this manner, a cured resin portion is formed around each of the electronic component chips on the substrate to resin-seal each of the electronic component chips. Thereafter, the cured resin portion is cut together with the substrate by, for example, blade dicing, and separated into electronic component packages (separating step). Techniques related to the above-described resin sealing of electronic component chips are described in, for example, Patent Document 1.

Citation List

Patent Document

[0005]

Patent Document 1: Japanese Unexamined Patent Publication No. 2015-53470

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0006]

The sealable resin sheet is required, in the pressing step, to be fluidized in a heat-softened state to have a flattened surface on the exposed side facing away from the electronic component chips (high fluidity requirement). The electronic-component-chip-facing side of the sealable resin sheet is required, in the curing step, that the constituent resin which is once softened by high-temperature heating enters not excessively into the gaps between the mounting substrate and the electronic component chips (low fluidity requirement). Thus, the sealable resin sheet is required to have different fluid properties on the chip facing side and the side opposite to the chip facing side when being softened by heat. The sealable resin sheet of Patent Document 1 has a layered structure of the first resin layer and the second resin layer which have different filler contents so as to satisfy the different requirements, where the first resin layer is a layer to be arranged on the chip facing side at the time of encapsulating the electronic component chips.

[0007]

In the sealable resin sheet of Patent Document 1, the ratio of the thickness of the first resin layer to the thickness of the second resin layer is from 0.05 to 0.3. In other words, the ratio of the thickness of the first resin layer to the entire thickness of the sealable resin sheet is from 0.048 to 0.23. When the sealable resin sheet has such a thin first layer, the higher the ratio of a mounting height (a height from the substrate surface to the chip's top surface facing away from the substrate) to a mounting interval between the electronic component chips on the substrate (a distance between the adjacent chips) is, the more easily a part of the first resin layer on the chip facing side that covers a corner or ridge of a chip is broken or torn in the sealing step. Specifically, the larger the mounting heights of the electronic component chips on the substrate

are, the more the first resin layer is stretched and becomes thin to be easily broken in the pressing step. Similarly, the narrower the mounting intervals between the electronic component chips on the substrate are, the more the first resin layer is stretched and becomes thin to be easily broken in the pressing step.

[0008]

The sealable resin sheet or sealable resin material has an internal stress after heat-curing in the curing step. The internal stress may warp the workpiece obtained through the curing step, where the workpiece is, for example, the one in which the electronic component chips are sealed with the sealable resin sheet on the substrate. When the warp of the workpiece is too large, the process after the curing step cannot appropriately be carried out. For example, such a warp hinders appropriate laser marking on a surface of a product of the resin sealed body.

[0009]

The present invention provides a sealable resin sheet for resin-sealing electronic component chips mounted on a base material in a state of facing the base material through a gap. The sealable resin sheet is suitable to achieve excellent hollow encapsulation even when the ratio of the mounting height to the mounting interval between the electronic component chips is high. The present invention also provides an electronic component device including an electronic component chip sealed with the sealable resin sheet of the present invention.

MEANS FOR SOLVING THE PROBLEM

[0010]

The present invention [1] includes a sealable resin sheet including: a first sealable resin layer and a second sealable resin layer sequentially in a thickness direction, wherein the first sealable resin layer contains a first thermosetting resin and a first inorganic filler, and has, after curing, an average coefficient of thermal expansion of 20 ppm/°C or less in a temperature range from -40°C to a glass transition temperature of the first sealable resin layer, the second sealable resin layer contains a second thermosetting resin and a second inorganic filler, and has, after curing, an average coefficient of thermal expansion of 20 ppm/°C or less in a temperature range from -40°C to a glass transition temperature of the second sealable resin layer, a content ratio of the first inorganic filler in the first sealable resin layer differs from a content ratio of the second

inorganic filler in the second sealable resin layer, and a ratio of a thickness of the first sealable resin layer to an entire thickness of the sealable resin sheet is 0.37 or more and 0.82 or less.

[0011]

The sealable resin sheet can be used to seal the electronic component chips, which are mounted on the base material in a state of facing the base material through a gap, through the pressing step and curing step as described below. In the pressing step, the sheet is pressed to the base material while being softened by heating, in a state that the first-sealable-resin-layer side of the sealable resin sheet is in contact with the electronic component chips on the base material. In this step, the first sealable resin layer closes the gaps along the side surfaces of the electronic component chips in a state that the first sealable resin layer is in tight contact with the base material around the electronic component chips. In the curing step, the sealable resin sheet covering the electronic component chips is further heated to a higher temperature and cured. In this manner, the cured resin portion is formed around the electronic component chips on the base material, and the electronic component chips are sealed with resin. The sealable resin sheet has the first sealable resin layer disposed on the first side that is the electronic-component-chip side and the second sealable resin layer disposed on the second side opposite to the first side in the sealing process, and the content ratio of the first inorganic filler in the first sealable resin layer differs from the content ratio of the second inorganic filler in the second sealable resin layer. Such a multi-layered structure is suitable to develop the different properties in the first sealable resin layer and the second sealable resin layer. Specifically, the structure is suitable to develop a high fluidity of the second sealable resin layer in order to facilitate the flattening of the second side, which is an exposed surface side, of the sealable resin sheet, and to develop a low fluidity of the first sealable resin layer in order to prevent the sealable resin, which is once softened by the high temperature heating, from excessively entering the gaps between the base material and the electronic component chips in the curing step.

[0012]

In the sealable resin sheet, the ratio of the thickness of the first sealable resin layer to the entire thickness of the sealable resin sheet is, as described above, 0.37 or more. Such a structure is suitable to suppress breakage of a part of the first sealable resin layer covering a

corner or ridge of a chip in the pressing step even when the ratio of the mounting height to the mounting interval between the electronic component chips is high. Such suppression of the breakage of the first sealable resin layer is suitable to suppress the flow of a part of the second sealable resin layer into the electronic-component-chip side through the broken part of the first sealable resin layer. On the assumption that the second sealable resin layer having a higher fluidity than the first sealable resin layer flows as described above in the pressing step, the flowing resin passes between the electronic component chip and the first sealable resin layer, reaches the gap between the base material and the electronic component chip, and consequently excessively enters the gap. The sealable resin sheet is suitable to avoid such a disadvantage.

[0013]

Further, the ratio of the thickness of the first sealable resin layer to the entire thickness to the sealable resin sheet is, as described above, 0.82 or less. Such a structure is suitable to ensure the fluidity of the sealable resin sheet as a whole and fill the gaps between the adjacent chips with the sealable resin even when the ratio of the mounting height to the mounting interval between the electronic component chips is high.

[0014]

Furthermore, the first and second sealable resin layers of the sealable resin sheet each have an average coefficient of thermal expansion of 20 ppm/°C or less in a range of the temperatures from -40°C to the glass transition temperature of the layer after the curing as described above. Such a configuration is suitable to suppress the internal stress in the first and second sealable resin layers of the sealable resin sheet, where the first and second sealable resin layers are cooled down to, for example, a room temperature after curing by the high-temperature heating. The suppression of the internal stress in the first and second sealable resin layers after the curing is suitable to suppress a warp of an electronic component device that is a resin sealed body produced with the sealable resin sheet. The suppression of the warp is suitable to suppress the detachment of the cured resin portion formed of the sealable resin sheet from the base material.

[0015]

The present invention [2] includes the sealable resin sheet described in [1], wherein the first sealable resin layer has a thickness of 90 μm or more.

[0016]

Such a structure is preferable for the above-described suppression of the breakage of the first sealable resin layer in the pressing step.

[0017]

The present invention [3] includes the sealable resin sheet described in [1] or [2], wherein the first sealable resin layer has the lowest melt viscosity of 120 $\text{kPa}\cdot\text{s}$ or more.

[0018]

Such a configuration is preferable to suppress the excessive entry of the first sealable resin layer into the gaps between the base material and the electronic component chips in the curing step, where the first sealable resin layer is once softened by the high-temperature heating.

[0019]

The present invention [4] includes the sealable resin sheet described in any one of the above-described [1] to [3], wherein the first sealable resin layer has the lowest melt viscosity of 260 $\text{kPa}\cdot\text{s}$ or less.

[0020]

Such a configuration is preferable to ensure the fluidity of the sealable resin sheet as a whole and fill the gaps between the adjacent chips with the sealable resin in the pressing step.

[0021]

The present invention [5] includes the sealable resin sheet described in any one of the above-described [1] to [4], further including: a third sealable resin layer between the first sealable resin layer and the second sealable resin layer, wherein the third sealable resin layer contains a third thermosetting resin and a third inorganic filler, and has, after curing, an average coefficient of thermal expansion of 20 $\text{ppm}/^\circ\text{C}$ or less in a temperature range from -40°C to a glass transition temperature of the third sealable resin layer.

[0022]

That the sealable resin sheet includes the above-described third sealable resin layer in addition to the first sealable resin layer is preferable to suppress the flow of the second sealable resin layer into the electronic-component-chip side in the pressing step.

[0023]

The present invention [6] includes the sealable resin sheet described in [5], wherein the third sealable resin layer is in direct contact with the first sealable resin layer, and a ratio of a total thickness of a thickness of the first sealable resin layer and a thickness of the third sealable resin layer to an entire thickness of the sealable resin sheet is 0.4 or more and 0.82 or less.

[0024]

Such a structure is preferable to suppress the flow of the second sealable resin layer into the electronic-component-chip side in the pressing step.

[0025]

The present invention [7] includes the sealable resin sheet described in any one of the above-described [1] to [6], wherein the content ratio of the inorganic filler in each of the sealable resin layers is 75% by mass or more.

[0026]

Such a structure is preferable to allow each of the sealable resin layers to have an average coefficient of thermal expansion of 20 ppm/°C or less after curing.

[0027]

The present invention [8] includes the sealable resin sheet described in any one of the above-described [1] to [7], wherein the content ratio of the inorganic filler in each of the sealable resin layers is 90% by mass or less

[0028]

Such a configuration is preferable to ensure the desired fluidity of the sealable resin sheet in the pressing step.

[0029]

The present invention [9] includes an electronic component device including: a base material; an electronic component chip mounted on the base material in a state in which the electronic component chip faces the base material through a gap; and a cured resin portion

formed of the sealable resin sheet in any one of the above-described [1] to [8], the cured resin portion encapsulating the electronic component chip and the gap.

[0030]

That the electronic component device includes the electronic component chip sealed with the cured resin portion formed of the above-described sealable resin sheet is suitable to achieve excellent encapsulating properties.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031]

FIG. 1 is a cross-sectional schematic view of one embodiment of the sealable resin sheet of the present invention.

FIG. 2A to FIG. 2C illustrate a method of sealing the electronic component chips on a base material with the sealable resin sheet of FIG. 1. FIG. 2A depicts a step of disposing a workpiece and the sealable resin sheet between the pressing plates of a plate pressing machine. FIG. 2B depicts a pressing step. FIG. 2C depicts a curing step.

FIG. 3 is a cross-sectional schematic view of a variation of the sealable resin sheet of FIG. 1. This variation of the sealable resin sheet has a three-layer structure.

FIG. 4A depicts a step of preparing a sealable resin sheet. FIG. 4B depicts a step of disposing a workpiece and the sealable resin sheet between the pressing plates of a plate pressing machine. FIG. 4C depicts a pressing step. FIG. 4D depicts a curing step.

DESCRIPTION OF THE EMBODIMENTS

[0032]

A sealable resin sheet X to be described as one embodiment of the sealable resin sheet of the present invention is a sheet-shaped sealable resin material for sealing an electronic component chip such as a semiconductor chip. As illustrated in FIG. 1, the sealable resin sheet X includes a sealable resin layer 11 and a sealable resin layer 12 sequentially in a thickness direction D. The sealable resin sheet X extends in a direction orthogonal to the thickness D.

[0033]

The sealable resin layer 11 is a layer formed of a first thermosetting composition. The first thermosetting composition contains a first thermosetting resin and a first inorganic filler.

In other words, the sealable resin layer 11 contains the first thermosetting resin and the first inorganic filler. The sealable resin layer 11 is in a semi-cured state (in B stage).

[0034]

Examples of the first thermosetting resin include epoxy resin, silicone resin, urethane resin, polyimide resin, urea resin, melamine resin, and unsaturated polyester resin. These first thermosetting resins can be used alone or in combination of two or more. A content ratio of the first thermosetting resin in the first thermosetting composition is preferably 3% by mass or more, more preferably 3.5% by mass or more. The content ratio of the first thermosetting resin in the first thermosetting composition is preferably 30% by mass or less, more preferably 25% by mass or less.

[0035]

The first thermosetting resin preferably includes an epoxy resin. Examples of the epoxy resin include bifunctional epoxy resins and trifunctional or more of multifunctional epoxy resins. Examples of the bifunctional epoxy resins include bisphenol A epoxy resin, bisphenol F epoxy resin, modified bisphenol A epoxy resin, modified bisphenol F epoxy resin, and biphenyl epoxy resin. Examples of the trifunctional or more of multifunctional epoxy resins include phenol novolak epoxy resin, cresol novolak epoxy resin, trishydroxyphenyl methane epoxy resin, tetraphenylol ethane epoxy resin, and dicyclopentadiene epoxy resin. These epoxy resins can be used alone or in combination of two or more. As the epoxy resin, preferably a bifunctional epoxy resin is used, and more preferably a bisphenol F epoxy resin and/or bisphenol A epoxy resin are/is used.

[0036]

An epoxy equivalent of the epoxy resin is preferably 10 g/eq or more, more preferably 50 g/eq or more, even more preferably 100 g/eq or more. The epoxy equivalent of the epoxy resin is preferably 650 g/eq or less, more preferably 600 g/eq or less, even more preferably 550 g/eq or less. When the first thermosetting resin contains several types of epoxy resin, a weighted average epoxy equivalent of the epoxy resins is preferably 10 g/eq or more, more preferably 50 g/eq or more, even more preferably 100 g/eq or more. The weighted average

epoxy equivalent is preferably 650 g/eq or less, more preferably 600 g/eq or less, even more preferably 550 g/eq or less.

[0037]

When the epoxy resin is used, the first thermosetting resin preferably contains a phenol resin as a curing agent for the epoxy resin. Such a configuration is suitable to allow the sealable resin sheet X to exhibit a high heat resistance and a high chemical resistance after curing, and accordingly suitable to produce a sealing material with an excellent encapsulating reliability. Preferable examples of the phenol resin include novolak phenol resins and triphenylmethane phenol resins. Examples of the phenol novolak resins include phenol novolak resins, phenol aralkyl resins, tris hydroxyphenyl methane novolak resins, cresol novolak resins, tert-butylphenol novolak resins, and nonylphenol novolak resins. These phenol resins can be used alone or in combination of two or more.

[0038]

In the first thermosetting composition, a hydroxyl group content in the phenol resin as the curing agent is preferably 0.7 equivalents or more, more preferably 0.9 equivalents or more with respect to 1 equivalent of the epoxy group in the epoxy resin. In the first thermosetting composition, the hydroxyl group content in the phenol resin as the curing agent is preferably 1.5 equivalents or less, more preferably 1.2 equivalents or less with respect to 1 equivalent of the epoxy group in the epoxy resin. An amount of the phenol resin contained as the curing agent is preferably 20 parts by mass or more, more preferably 40 parts by mass or more with respect to 100 parts by mass of the epoxy resin. The amount of the phenol resin contained as the curing agent is preferably 80 parts by mass or less, more preferably 60 parts by mass or less with respect to 100 parts by mass of the epoxy resin.

[0039]

The first thermosetting composition preferably includes a curing accelerator. The curing accelerator is a catalyst (thermosetting catalyst) that promotes curing reaction of the thermosetting resin by heating. Examples of the curing accelerator include imidazole compounds and organic phosphorus compounds. Examples of the imidazole compounds include 2-phenyl-4, 5-dihydroxy methyl imidazole and 2-phenyl-4-methyl-5-hydroxymethyl

imidazole. Examples of the organic phosphorus compounds include triphenylphosphine, tricyclohexylphosphine, tributylphosphine, and methyldiphenylphosphine. Preferably an imidazole compound, more preferably 2-phenyl-4, 5-dihydroxy methyl imidazole is used as the curing accelerator. An amount of the contained curing accelerator is for example, 0.05 parts by mass or more, and, for example, 5 parts by mass or less with respect to 100 parts by mass of the first thermosetting resin.

[0040]

Examples of the first inorganic filler include a layered silicate compound and an inorganic filler other than the layered silicate compound. The first inorganic filler preferably contains a layered silicate compound and an inorganic filler other than the layered silicate compound.

[0041]

The layered silicate compound is a component that increases the viscosity of the first thermosetting composition while developing the thixotropy of the first thermosetting composition, and dispersed in the first thermosetting composition. Examples of the layered silicate compound include smectite, kaolinite, halloysite, talc, and mica. Examples of the smectite include montmorillonite, beidellite, non-tronite, saponite, hectorite, sauconite, and stevensite. Because of their high mixability with the thermosetting resin, preferably smectite, more preferably montmorillonite is used as the layered silicate compound.

[0042]

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 obtain excellent affinity with the first thermosetting resin, preferably a layered silicate compound having a surface modified by an organic component, more preferably an organic smectite having a surface modified by an organic component is used. Even more preferably, an organic bentonite having a surface modified by an organic component is used.

[0043]

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

[0044]

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

[0045]

An average particle size of the layered silicate compound is preferably 1 nm or more, more preferably 5 nm or more, even more preferably 10 nm or more. The average particle size of the layered silicate compound is preferably 100 μm or less, more preferably 50 μm or less, even more preferably 10 μm or less. The average particle size of the layered silicate compound is a median diameter in the particle size distribution on the basis of volume, i.e., a particle size where the cumulative frequency in volume reaches 50% from the smallest particle size, and the average particle size is obtained, for example, based on the particle size distribution obtained by a laser diffraction method. The same applies to the average particle size of the other inorganic fillers.

[0046]

A commercialized product can be used as the layered silicate compound. Examples of the commercialized product of organic bentonite include the S-Ben series manufactured by HOJUN Co., Ltd.

[0047]

A content ratio of the layered silicate compound in the first thermosetting composition, namely, a content ratio of the layered silicate compound in the sealable resin layer 11 is preferably 1% by mass or more, more preferably 1.2% by mass or more, even more preferably 1.4% by mass or more. Such a configuration is suitable to increase the viscosity of the sealable resin layer 11 and develop the thixotropy that makes the viscosity of the sealable resin layer 11 under pressure lower than the viscosity without pressure. The content ratio of the layered silicate compound in the first thermosetting composition is preferably 6% by mass or less, more preferably 5% by mass or less, even more preferably 4% by mass or less to avoid excessive increase in the viscosity of the first thermosetting composition.

[0048]

Examples of the inorganic filler other than the layered silicate compound include silicon compounds other than the layered silicate compound, such as silica and silicon nitride; and silicate salt compounds other than the layered silicate compound, such as orthosilicate salt, sorosilicate salt, and inosilicate salt. Examples of the inorganic filler other than the layered silicate compound also include aluminum hydroxide, magnesium hydroxide, calcium carbonate, magnesium carbonate, calcium oxide, magnesium oxide, aluminum oxide, aluminum nitride, aluminum borate whiskers, and boron nitride. These inorganic fillers can be used alone or in combination of two or more. Preferably a silicon compound other than the layered silicate compound, more preferably silica is used as the inorganic filler.

[0049]

The inorganic filler other than the layered silicate compound may be in, for example, an approximately spherical shape, an approximately planar shape, an approximately aciculate shape, or an amorphous shape. An approximately spherical shape is preferred.

[0050]

An average particle size of the particles of the inorganic filler other than the layered silicate compound (an average value of the maximum lengths of the particles of the inorganic filler when the inorganic filler particles have a shape other than an approximately spherical shape) is preferably 0.1 μm or more, more preferably 0.5 μm or more. The average particle size is preferably 50 μm or less, more preferably 20 μm or less, even more preferably 10 μm or less.

[0051]

The inorganic filler other than the layered silicate compound may have a surface partially or wholly treated with a surface treatment agent, such as a silane coupling agent.

[0052]

A content ratio of the inorganic filler other than the layered silicate compound in the first thermosetting composition is preferably 73% by mass or more, more preferably 76% by mass or more, even more preferably 78% by mass or more. Such a configuration is suitable to suppress the expansion and contraction of the sealable resin layer 11 with temperature change. The content ratio is preferably 90% by mass or less, more preferably 85% by mass or less, even more preferably 83% by mass or less. Such a configuration is suitable to avoid excessive increase in the viscosity of the first thermosetting composition and ensure the fluidity of the sealable resin layer 11 in the pressing step described below.

[0053]

A content ratio R1 of the first inorganic filler in the first thermosetting composition, or the sealable resin layer 11, is preferably 75% by mass or more, more preferably 78% by mass or more, even more preferably 80% by mass or more. Such a configuration is suitable to suppress the expansion and contraction of the sealable resin layer 11 with temperature change and preferable to achieve an average coefficient of thermal expansion of 20 ppm/ $^{\circ}\text{C}$ or less after curing. The content ratio R1 is preferably 90% by mass or less, more preferably 87% by mass or less, even more preferably 85% by mass or less. Such a configuration is suitable to avoid excessive increase in the viscosity of the first thermosetting composition and ensure the fluidity of the sealable resin layer 11 in the pressing step described below.

[0054]

A ratio of the layered silicate compound in the first inorganic filler is preferably 0.5% by mass or more, more preferably 1% by mass or more, even more preferably 1.5% by mass or more. The ratio is preferably 8% by mass or less, more preferably 7% by mass or less, even more preferably 6.5% by mass or less. Such a configuration is suitable to suppress the expansion and contraction of the sealable resin layer 11 with temperature change, ensure the fluidity in the pressing step described below, and develop the above-described thixotropy, while keeping a proper balance therebetween.

[0055]

The first thermosetting composition may contain another component. Examples of another component include thermoplastic resins, pigments, and silane coupling agents.

[0056]

Examples of the thermoplastic resin include acrylic resin, 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, phenoxy resin, saturated polyester resin such as PET, 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.

[0057]

Preferably, acrylic resin is used as the thermoplastic resin to ensure the mutual solubility between the thermosetting resin and the thermoplastic resin.

[0058]

Examples of the acrylic resin include a (meth)acrylate copolymer that is a polymer of monomer components containing an alkyl (meth)acrylate having a straight-chain or branched alkyl group and another monomer that is a copolymerizable monomer.

[0059]

Examples of the alkyl group of the alkyl (meth)acrylate include an alkyl group having one to six carbon atoms. Examples of the alkyl group include a methyl group, an ethyl group, a propyl group, an isopropyl group, an n-butyl group, a t-butyl group, an isobutyl group, a pentyl group, and a hexyl group.

[0060]

Examples of the copolymerizable monomer include carboxyl group-containing monomers, acid anhydride monomers, glycidyl group-containing monomers, hydroxyl group-containing monomers, sulfonate group-containing monomers, phosphate group-containing monomers, and acrylonitrile. Examples of the carboxyl group-containing monomer include acrylic acid, methacrylic acid, carboxyethyl acrylate, carboxypentyl acrylate, itaconic acid, maleic acid, fumaric acid, and crotonic acid. Examples of the acid anhydride monomer include maleic anhydride and itaconic acid anhydride. Examples of the glycidyl group-containing monomer include glycidyl acrylate and glycidyl methacrylate. Examples of the hydroxyl group-containing monomer include 2-hydroxyethyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate, 4-hydroxybutyl (meth)acrylate, 6-hydroxyhexyl (meth)acrylate, 8-hydroxyoctyl (meth)acrylate, 10-hydroxydecyl (meth)acrylate, and 12-hydroxylauryl (meth)acrylate. Examples of the sulfonate group-containing monomer include styrenesulfonate, allylsulfonate, 2-(meth)acrylamide-2-methylpropanesulfonate, (meth)acrylamidepropanesulfonate, sulfopropyl (meth)acrylate, and (meth)acryloyl oxynaphthalenesulfonate. Examples of the phosphate group-containing monomer include 2-hydroxyethylacryloylphosphate. These copolymerizable monomers can be used alone or in combination of two or more.

[0061]

The thermoplastic resin preferably has a glass transition temperature (T_g) of -70°C or more. The glass transition temperature is preferably 0°C or less, more preferably -5°C or less.

[0062]

To calculate the glass transition temperature (T_g) of the polymer, a theoretical value of a glass transition temperature obtained based on the following Fox equation is used. The Fox equation shows the relation between the glass transition temperature T_g of the polymer and the glass transition temperature T_{gi} of a homopolymer of the monomer that forms the polymer. In the following Fox equation, T_g represents the glass transition temperature ($^{\circ}\text{C}$) of the polymer, W_i represents the weight fraction of a monomer i forming the polymer, and T_{gi} represents the glass transition temperature ($^{\circ}\text{C}$) of the homopolymer formed of the monomer i . A literature data can be used as the glass transition temperature of the homopolymer. For example, the

glass transition temperatures of a variety of homopolymers are cited in “Polymer Handbook” (Forth Edition, John Wiley & Sons, Inc., 1999) and “new polymer paperback 7 Introduction to coating synthetic polymer” (KITAOKA, Kyoza. Polymer Journal, 1995). Alternatively, the glass transition temperature of the homopolymer of the monomer may be obtained by the method described in detail in Japanese Unexamined Patent Publication No.2007-51271.

[0063]

The Fox equation $1 / (273 + T_g) = \sum [W_i / (273 + T_{gi})]$

[0064]

A weight average molecular weight of the thermoplastic resin is preferably 100,000 or more, preferably 300,000 or more. The weight average molecular weight of the thermoplastic resin is preferably 2,000,000 or less, more preferably 1,000,000 or less. The weight average molecular weight of the resin is calibrated with standard polystyrene based on gel permeation chromatography (GPC).

[0065]

A content ratio of the thermoplastic resin in the first thermosetting composition is preferably 1% by mass or more, more preferably 2% by mass or more. The content ratio is preferably 80% by mass or less, more preferably 60% by mass or less.

[0066]

Examples of the pigment include black pigments such as carbon black. The particle size of the pigment is, for example, 0.001 μm or more, and, for example, 1 μm or less. The particle size of the pigment is an arithmetic average particle size obtained by observing the pigment with an electron microscope. A content ratio of the pigment in the first thermosetting composition is, for example, 0.1% by mass or more, and, for example, 2% by mass or less.

[0067]

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 dialkoxysilanes and 3-glycidoxy alkyl trialkoxysilanes. Examples of the 3-glycidoxy dialkyl dialkoxysilanes include 3-glycidoxy propyl methyl dimethoxy silane and 3-glycidoxy propyl methyl diethoxy silane. Examples of the 3-glycidoxy alkyl trialkoxysilanes

include 3-glycidoxy propyl trimethoxy silane and 3-glycidoxy propyl triethoxy silane. Preferably a 3-glycidoxy alkyl trialkoxy silane, more preferably 3-glycidoxy propyl trimethoxy silane is used as the silane coupling agent. A content ration of the silane coupling agent in the first thermosetting composition is preferably 0.1% by mass or more, more preferably 1% by mass or more. The content ratio is preferably 10% by mass or less, more preferably 5% by mass or less.

[0068]

The sealable resin layer 12 is a layer formed of a second thermosetting composition. The second thermosetting composition contains a second thermosetting resin and a second inorganic filler. In other words, the sealable resin layer 12 contains the second thermosetting resin and the second inorganic filler. The sealable resin layer 12 is in a semi-cured state (B stage).

[0069]

Examples of the second thermosetting resin include the above-described first thermosetting resin. A content ratio of the second thermosetting resin in the second thermosetting composition is preferably 3% by mass or more, more preferably 3.5% by mass or more. The content ratio of the second thermosetting resin in the second thermosetting composition is preferably 30% by mass or less, more preferably 25% by mass or less.

[0070]

The second thermosetting resin preferably contains an epoxy resin. Examples of the epoxy resin include the epoxy resins described above for the first thermosetting composition. Preferably a bifunctional epoxy resin is used. More preferably bisphenol A epoxy resin and/or bisphenol F epoxy resin are/is used. A preferable range of the epoxy equivalent of the epoxy resin in the second thermosetting composition is the same as the above-described preferable range of the epoxy equivalent of the epoxy resin in the first thermosetting composition.

[0071]

When an epoxy resin is used as the second thermosetting resin, the second thermosetting resin preferably includes a phenol resin as a curing agent for the epoxy resin. Preferable examples of the phenol resin include novolak phenol resin and triphenylmethane

phenol resin. A hydroxyl group content in the phenol resin contained as the curing agent with respect to 1 equivalent of the epoxy group of the epoxy resin in the second thermosetting composition is the same as the content of the hydroxyl group in the phenol resin contained as the curing agent with respect to 1 equivalent of the epoxy group of the epoxy resin in the first thermosetting composition. An amount of the phenol resin blended as the curing agent with respect to 100 parts by mass of the epoxy resin in the second thermosetting composition is the same as the amount of the phenol resin blended as the curing agent with respect to 100 parts by mass of the epoxy resin in the first thermosetting composition.

[0072]

The second thermosetting composition preferably includes a curing accelerator. Examples of the curing accelerator include the curing accelerators described above for the first thermosetting composition. An amount of the curing accelerator blended with respect to 100 parts by mass of the second thermosetting resin is for example, 0.05 parts by mass or more, and, for example, 5 parts by mass or less.

[0073]

Examples of the second inorganic filler include the first inorganic filler described above for the first thermosetting composition. Preferably an inorganic filler other than the layered silicate compound, more preferably a silicon compound other than the layered silicate compound, even more preferably silica is used as the second inorganic filler.

[0074]

The second inorganic filler may be in, for example, an approximately spherical shape, an approximately planar shape, an approximately aciculate shape, or an amorphous shape. An approximately spherical shape is preferred. An average particle size of the particles of the second inorganic filler (an average value of the maximum lengths of the particles of the second inorganic filler when the second inorganic filler particles have a shape other than an approximately spherical shape) is preferably 0.1 μm or more, more preferably 0.5 μm or more. The average particle size is preferably 50 μm or less, more preferably 20 μm or less, even more preferably 10 μm or less. The second inorganic filler may have a surface partially or wholly treated with a surface treatment agent, such as a silane coupling agent.

[0075]

A content ratio R2 of the second inorganic filler in the second thermosetting composition, or the sealable resin layer 12, differs from the content ratio R1 of the first inorganic filler in the sealable resin layer 11. The content ratio R2 is, for example, higher than the content ratio R1, and, for example, lower than the content ratio R1.

[0076]

The content ratio R2 of the second inorganic filler in the second thermosetting composition is preferably 75% by mass or more, more preferably 78% by mass or more, even more preferably 80% by mass or more as long as the ratio R2 is different from the ratio R1. Such a configuration is suitable to suppress the expansion and contraction of the sealable resin layer 12 with temperature change and preferable to achieve an average coefficient of thermal expansion of 20 ppm/°C or less after curing. The content ratio R2 is preferably 90% by mass or less, more preferably 87% by mass or less, even more preferably 85% by mass or less as long as the ratio R2 is different from the ratio R1. Such a configuration is suitable to ensure the fluidity of the sealable resin layer 12 in the pressing step described below.

[0077]

The second thermosetting composition may contain another component. Examples of another component include the thermoplastic resins, pigments, and silane coupling agents described above for the first thermosetting composition.

[0078]

The sealable resin sheet X is produced by, for example, forming each of the sealable resin layer 11 and the sealable resin layer 12 and then bonding the sealable resin layer 11 and the sealable resin layer 12 together.

[0079]

The sealable resin layer 11 is formed, for example, as follows. First, the components and solvent described above for the first thermosetting composition are mixed in a predetermined ratio, thereby preparing a varnish of the first thermosetting composition. Examples of the solvent include methyl ethyl ketone, ethyl acetate, and toluene. Next, the varnish is applied on a base material, such as a release sheet, to form a coating film. Thereafter, the coating film is

dried by heating. In this manner, the sealable resin layer 11 is formed in a shape of a sheet and in a semi-cured state.

[0080]

The sealable resin layer 12 may be formed, for example, as follows. The components and solvents described above for the second thermosetting composition are mixed in a predetermined ratio, thereby preparing a varnish of the second thermosetting composition. Next, the varnish is applied on a base material, such as a release sheet, to form coating film. Thereafter, the coating film is dried by heating. In this manner, the sealable resin layer 12 is formed in a shape of a sheet and in a semi-cured state.

[0081]

The sealable resin sheet X may be produced by forming a sealable resin layer 11 on a base material and then forming a sealable resin layer 12 on the sealable resin layer 11. Alternatively, the sealable resin sheet X is produced by forming a sealable resin layer 12 on a base material and then forming a sealable resin layer 11 on the sealable resin layer 12.

[0082]

A ratio of the thickness H1 of the sealable resin layer 11 to the entire thickness of the sealable resin sheet X is 0.37 or more, preferably 0.4 or more, more preferably 0.5 or more, even more preferably 0.6 or more. In other words, a ratio of a thickness H2 of the sealable resin layer 12 to the entire thickness of the sealable resin sheet X is 0.63 or less, preferably 0.6 or less, more preferably 0.5 or less, even more preferably 0.4 or less. Such a structure is suitable to suppress the breakage of the sealable resin layer 11 in the pressing step described below.

[0083]

The ratio of the thickness H1 of the sealable resin layer 11 to the entire thickness of the sealable resin sheet X is 0.82 or less, preferably 0.8 or less. In other words, the ratio of the thickness H2 of the sealable resin layer 12 to the entire thickness of the sealable resin sheet X is 0.18 or more, preferably 0.2 or more. Such a structure is suitable to ensure the fluidity of the sealable resin sheet X as a whole in the pressing step described below and fill the gaps between the adjacent chips with the sealable resin.

[0084]

The sealable resin layer 11 has a thickness of preferably 90 μm or more, more preferably 100 μm or more, even more preferably 120 μm or more. Such a structure is preferable to suppress the breakage of the sealable resin layer 11 in the pressing step described below. The sealable resin layer 11 has a thickness of, for example, 300 μm or less, more preferably 250 μm or less, even more preferably 200 μm or less, particularly preferably 180 μm or less. Such a structure is preferable to ensure the fluidity of the sealable resin sheet X as a whole in the pressing step described below and fill the gaps between the adjacent chips with the sealable resin.

[0085]

The thickness H2 of the sealable resin layer 12 is preferably 30 μm or more, more preferably 50 μm or more, even more preferably 80 μm or more, particularly preferably 100 μm or more. The thickness H2 of the sealable resin layer 12 is, for example, 300 μm or less, preferably 250 μm or less, more preferably 200 μm or less, particularly preferably 180 μm or less.

[0086]

The entire thickness of the sealable resin sheet X is preferably 150 μm or more, more preferably 200 μm or more, even more preferably 230 μm or more. The entire thickness of the sealable resin sheet X is preferably 500 μm or less, more preferably 400 μm or less, even more preferably 300 μm or less, particularly preferably 280 μm or less.

[0087]

The lowest melt viscosity of the sealable resin layer 11 is preferably 120 $\text{kPa}\cdot\text{s}$ or more, more preferably 150 $\text{kPa}\cdot\text{s}$ or more, even more preferably 180 $\text{kPa}\cdot\text{s}$ or more, particularly preferably 200 $\text{kPa}\cdot\text{s}$ or more. Such a configuration is preferable to suppress excessive entry of the sealable resin layer 11 into the gaps between the base material and the electronic component chips when the sealable resin layer 11 is once softened by high temperature heating in the curing step described below. The lowest melt viscosity of the sealable resin layer is obtained by a measurement of the viscoelasticity of the sealable resin layer. The viscoelasticity measurement is carried out with a rheometer. For example, "HAAKE MARS III" manufactured by Thermo Fisher Scientific is used as the rheometer. The measurement is carried out at a frequency of 1 Hz, a deformation value of 0.005%, a temperature range of 50°C to 90°C, and a rate of

temperature increase of 30°C/min. Specifically, the lowest melt viscosity is obtained by a measurement method described in Examples below.

[0088]

The lowest melt viscosity of the sealable resin layer 11 is preferably 260 kPa·s or less, more preferably 250 kPa·s or less, even more preferably 240 kPa·s or less. Such a configuration is preferable to ensure the fluidity of the sealable resin sheet X as a whole in the pressing step described below and fill the gaps between the adjacent chips with the sealable resin.

[0089]

The lowest melt viscosity of the sealable resin layer 12 is preferably 1 kPa·s or more, more preferably 3 kPa·s or more, and preferably 200 kPa·s or less, more preferably 180 kPa·s or less. Such a configuration is preferable to ensure the fluidity of the sealable resin sheet X as a whole in the pressing step described below and fill the gaps between the adjacent chips with the sealable resin.

[0090]

After being cured by heating at 150°C for one hour, the sealable resin layer 11 has an average coefficient of thermal expansion Z1 of 20 ppm/°C or less in a temperature range from -40°C to the glass transition temperature of the sealable resin layer 11. After being cured by heating at 150°C for one hour, the sealable resin layer 12 has an average coefficient of thermal expansion Z2 of 20 ppm/°C or less in a temperature range from -40°C to the glass transition temperature of the sealable resin layer 12. Such a configuration is suitable to suppress the internal stress in the sealable resin layers 11 and 12 of the sealable resin sheet X, where the sealable resin sheet X is cooled down to, for example, a room temperature after curing by the high temperature heating. The average coefficient of thermal expansion Z1 is preferably 18 ppm/°C or less, more preferably 17 ppm/°C or less. The average coefficient of thermal expansion Z2 is preferably 18 ppm/°C or less, more preferably 17 ppm/°C or less. The average coefficient of thermal expansion of the sealable resin layer is measured with a thermal mechanical analyzer (TMA). For example, "Q400 TMA" manufactured by TA Instruments Japan Inc. is used as the TMA. The measurement is carried out in a tensile mode, at a rate of temperature increase of 1°C/min, under a modulation condition of $\pm 5.000^\circ\text{C}/300$ sec, and in a

measurement temperature range from -40°C to 260°C. Specifically, the average coefficient of thermal expansion is obtained by a measurement method described below regarding Examples.

[0091]

A ratio of the average coefficient of thermal expansion Z2 to the average coefficient of thermal expansion Z1 is preferably 0.7 or more, more preferably 0.8 or more, even more preferably 0.9 or more, and preferably 1.3 or less, more preferably 1.2 or less, even more preferably 1.1 or less. Such a configuration is preferable to suppress the warp of the cured sealable resin sheet X.

[0092]

FIG. 2A to FIG. 2C show a method of sealing electronic component chips on a base material with the sealable resin sheet X.

[0093]

As illustrated in FIG. 2A, a workpiece W and the sealable resin sheet X are disposed between a first pressing plate P1 and a second pressing plate P2 of a plate pressing machine (disposing step).

[0094]

The workpiece W include a substrate S and a plurality of chips 21. The substrate S is a base material to be separated into the single mounting substrates, and has a mounting surface Sa. The mounting surface Sa is provided with a mounting terminal not illustrated. Each of the chips 21 is an electronic component chip, such as a semiconductor chip, and has a principal surface 21a and side surfaces 21b. The principal surface 21a is provided with an outer component connecting terminal not illustrated. The chips 21 are mounted on the substrate S via bump electrodes 22 in a state of facing the substrate S through gaps G. Each of the bump electrodes 22 intervenes between a terminal of the mounting surface Sa of the substrate S and a terminal of the principal surface 21a of each of the chips 21 to electrically connect the substrate S to the chips 21.

[0095]

A mounting height of the chips 21 on the substrate S, i.e., a height between the chip's top surface facing away from the substrate S and a surface of the substrate S on which the chips

21 are mounted is, for example, 200 μm or more, preferably 220 μm , more preferably 250 μm or more. The mounting height is, for example, 400 μm or less, preferably 350 μm or less, more preferably 300 μm or less.

[0096]

A separate distance between the substrate S and the chips 21 is, for example, 10 μm or more, preferably 15 μm or more, more preferably 20 μm or more. The separate distance is, for example, 80 μm or less, preferably 60 μm or less, more preferably 50 μm or less.

[0097]

The chips 21 are separated by mounting intervals in a surface direction on the mounting surface Sa of the substrate S. The mounting interval between the adjacent chips 21 is, for example, 50 μm or more, preferably 100 μm or more, more preferably 200 μm or more. The interval between the adjacent chips 21 is, for example, 10 mm or less, preferably 5 mm or less, more preferably 1 mm or less.

[0098]

In this step, the workpiece W is placed on the first pressing plate P1 so that the substrate S is in contact with the first pressing plate P1. The sealable resin sheet X is laminated on the workpiece W so that the sealable resin layer 11 is in contact with the chips 21 of the workpiece W.

[0099]

As illustrated in FIG. 2B, the sealable resin sheet X and the workpiece W are pressed by the first pressing plate P1 and the second pressing plate P2 in the thickness direction D (pressing step). Specifically, the sealable resin sheet X is pressed toward the substrate S while being softened by heating, in a state that the sealable resin layer 11 of the sealable resin sheet X is in contact with the chips 21 on the substrate S.

[0100]

The press is carried out at a pressing pressure of, for example, 0.01 MPa or more, preferably 0.05 MPa or more. The pressing pressure is, for example, 10 MPa or less, preferably 5 MPa or less. The press is carried out for a pressing time of, for example, 0.3 minutes or more, preferably 0.5 minutes or more. The pressing time is, for example, 10 minutes or less,

preferably 5 minutes or less. During the press, the heating is carried out at a heating temperature of, for example, 40°C or more, preferably 60°C or more. The heating temperature is, for example, 100°C or less, preferably 95°C or less.

[0101]

In this step, the sealable resin sheet X is deformed in conformity to the outer shape of the chips 21 while maintaining B stage, and covers the side surfaces 21b of each of the chips 21 to be in contact with the mounting surface Sa of the substrate S that does not overlap the chips 21 in a plan view. The open edges of the gaps G are closed with the sealable resin layer 11 along the side surfaces 21b of the chips 21 in a state that the sealable resin layer 11 is in tight contact with the substrate S around the chips 21 (the gaps G are encapsulated).

[0102]

The deformed sealable resin sheet X is allowed to slightly enter the gaps G between the substrate S and the chips 21. Specifically, the sealable resin sheet X is allowed to have an entry length L1 in which the sheet X enters the gap G based on the side surface 21b of the chip 21.

[0103]

The entry length L1 is preferably 50 μm or less, more preferably 30 μm or less. Such a structure is suitable to ensure a region in which a wire can be formed on the principal surface 21a of each of the chips 21 and to ensure a region in which a wire can be formed on the mounting surface Sa of the substrate S, and thus contributes to provide greater functionality of the resin sealed body. The entry length L1 is preferably 0 μm or more. Such a structure is suitable to properly encapsulate the chips 21 and gaps G to prevent the gaps G from having an opening to the outside of the resin sealed body when the resin sealed body is separated into electronic component devices.

[0104]

Next, after the sealing with the sealable resin sheet X, the workpiece W is taken out of the plate pressing machine and, as illustrated in FIG. 2C, the sealable resin sheet X is cured by heating in the curing step. In this manner, a cured resin portion is formed around each of the chips 21 on the substrate S, and the chips 21 are sealed with resin.

[0105]

The curing by heating is carried out at a temperature of, for example, 100°C or more, preferably 120°C or more. The heating and curing temperature is, for example, 200°C or less, preferably 180°C or less. The heating time is, for example, 10 minutes or more, preferably 30 minutes or more. The heating time is, for example, 180 minutes or less, preferably 120 minutes or less.

[0106]

The cured sealable resin sheet X has an entry length L2 of preferably 50 μm or less, more preferably 30 μm or less in the gaps G. Such a structure is suitable to secure a region in which a wire can be formed on the principal surface 21a of each of the chips 21, and also secure a region in which a wire can be formed on the mounting surface Sa of the substrate S, and thus contributes to provide greater functionality of the resin sealed body. The entry length L2 is preferably 0 μm or more. Such a structure is suitable to properly encapsulate the chip 21 and gap G to prevent the gap G from being opening to the outside of the resin sealed body after the resin sealed body is separated into electronic component devices.

[0107]

Thereafter, the cured sealable resin sheet X and substrate S are cut along predetermined lines by, for example, blade dicing and separated into electronic component devices as resin sealed bodies (separating step). The electronic component device produced as described above includes the substrate S as a base material, the chip 21 as an electronic component chip mounted on the substrate S and facing the substrate S through the gap G, and the cured resin portion formed of the sealable resin sheet X and encapsulating the chip 21 and gap G.

[0108]

The sealable resin sheet X includes the sealable resin layer 11 disposed at the chip 21 side that is the first side of the sealable resin sheet X and the sealable resin layer 12 disposed at the second side opposite to the first side in the sealing process described above, while the content ratio R1 of the first inorganic filler in the sealable resin layer 11 is different from the content ratio R2 of the second inorganic filler in the sealable resin layer 12. Such a structure is suitable to develop different properties in the sealable resin layer 11 and the sealable resin layer 12. Specifically, the structure is suitable to develop the high fluidity of the sealable resin layer 12 in

order to facilitate the flattening of the second side, which is the exposed surface side of the sealable resin sheet X, in the pressing step (FIG. 2B), and to simultaneously develop the low fluidity of the sealable resin layer 11 in order to prevent the sealable resin from excessively entering the gaps G between the substrate S and the chips 21 while the sealable resin is once softened by the high temperature heating in the curing step (FIG. 2C).

[0109]

Further, the ratio of the thickness of the sealable resin layer 11 to the entire thickness of the sealable resin sheet X is, as described above, 0.37 or more, preferably 0.4 or more, more preferably 0.5 or more, even more preferably 0.6 or more. Such a structure is suitable to suppress the breakage of a part of the sealable resin layer 11 covering a corner or ridge of a chip 21 in the pressing step (FIG. 2B) even when the ratio of the mounting height to the mounting interval between the chips 21 is high. Such suppression of the breakage of the sealable resin layer 11 is suitable to suppress the flow of a part of the sealable resin layer 12 into the chip 21 side through the broken part of the sealable resin layer 11. If the flow of the sealable resin layer 12 with a higher fluidity than that of the sealable resin layer 11 occurs in the pressing step, the flowing resin passes between the chips 21 and the sealable resin layer 11, and reaches a gap G between the substrate S and the chips 21. Consequently, the flowing resin excessively enters the gap G. The sealable resin sheet X is suitable to avoid such a disadvantage.

[0110]

Furthermore, the ratio of the thickness H1 of the sealable resin layer 11 to the entire thickness of the sealable resin sheet X is, as described above, 0.82 or less, preferably 0.8 or less. Such a structure is suitable to ensure the fluidity of the sealable resin sheet X as a whole and fill the gaps between the adjacent chips 21 with the sealable resin in the pressing step (FIG. 2B) even when the ratio of the mounting height to the mounting interval between the chips 21 is high.

[0111]

Furthermore, as described above, each of the sealable resin layers of the sealable resin sheet X has, after curing, an average coefficient of thermal expansion of 20 ppm/°C or less in a temperature range from -40°C to the glass transition temperature of the layer. Such a configuration is suitable to suppress the internal stress in each of the sealable resin layers, where

the sealable resin layer is cooled down to, for example, a room temperature after curing by the high temperature heating. Such suppression of the internal stress of the sealable resin layers after curing is suitable to suppress a warp of the electronic component device as a resin sealed body produced with the sealable resin sheet X. The suppression of the warp is suitable to suppress the detachment of the cured resin portion formed of the sealable resin sheet X from the substrate S.

[0112]

The sealable resin layer 11, as described above, preferably contains the layered silicate compound. Such a configuration is suitable to increase the viscosity of the sealable resin layer 11 and to simultaneously develop the thixotropy of the sealable resin layer 11 that makes the viscosity of the sealable resin layer 11 under pressure lower than the viscosity without pressure. The development of the thixotropy of the sealable resin layer 11 is suitable to allow the sealable resin layer 11 to be soften and move together with the sealable resin layer 12 by pressure and to deform in conformity to the outer shapes of the chips 21 in the pressing step (FIG. 2B). The increase in the viscosity of the sealable resin layer 11 is suitable to suppress the decrease in the viscosity of the sealable resin layer 11 due to the temperature increase and suppress the excessive entry of the sealable resin into the gaps G in the curing step (FIG. 2C).

[0113]

The sealable resin sheet X may further include at least one layer between the sealable resin layers 11 and 12. FIG. 3 illustrates an example in which the sealable resin sheet X includes a sealable resin layer 13 between the sealable resin layers 11 and 12. The sealable resin layer 13 is in direct contact with the sealable resin layers 11 and 12. The sealable resin sheet X further including a sealable resin layer between the sealable resin layers 11 and 12 is preferable to suppress the flow of the sealable resin layer 12 to the electronic-component-chip side in the pressing step.

[0114]

The sealable resin layer 13 is a layer formed of a third thermosetting composition. The third thermosetting composition contains a third thermosetting resin and a third inorganic filler.

In other words, the sealable resin layer 13 contains the third thermosetting resin and the third inorganic filler. The sealable resin layer 13 is in a semi-cured state (B stage).

[0115]

Examples of the third thermosetting resin include the first thermosetting resin. A content ratio of the third thermosetting resin in the third thermosetting composition is preferably 3% by mass or more, more preferably 3.5% by mass or more. The content ratio of the third thermosetting resin in the third thermosetting composition is preferably 30% by mass or less, more preferably 25% by mass or less.

[0116]

The third thermosetting resin preferably contains an epoxy resin. Examples of the epoxy resin include the epoxy resins described above for the first thermosetting composition. Preferably a bifunctional epoxy resin is used. More preferably bisphenol A epoxy resin and/or bisphenol F epoxy resin are/is used. The preferred range of the epoxy equivalent of the epoxy resin in the third thermosetting composition is the same as the above-given preferred range of the epoxy equivalent of the epoxy resin in the first thermosetting composition.

[0117]

When an epoxy resin is used as the third thermosetting resin, the third thermosetting resin preferably contains a phenol resin as the curing agent for the epoxy resin. Preferable examples of the phenol resin include novolak phenol resin and triphenylmethane phenol resin. A hydroxyl group content in the phenol resin contained as the curing agent with respect to 1 equivalent of the epoxy group of the epoxy resin in the third thermosetting composition is the same as the hydroxyl group content in the phenol resin contained as the curing agent with respect to 1 equivalent of the epoxy group of the epoxy resin in the first thermosetting composition. An amount of the phenol resin blended as the curing agent with respect to 100 parts by mass of the epoxy resin in the third thermosetting composition is the same as the amount of the phenol resin blended as the curing agent with respect to 100 parts by mass of the epoxy resin in the first thermosetting composition.

[0118]

The third thermosetting composition preferably includes a curing accelerator.

Examples of the curing accelerator include the curing accelerators described above for the first thermosetting composition. The amount of the curing accelerator blended with respect to 100 parts by mass of the third thermosetting resin is for example, 0.05 parts by mass or more, and, for example, 5 parts by mass or less.

[0119]

Examples of the third inorganic filler include the first inorganic fillers (the layered silicate compound and the inorganic filler other than the layered silicate compound) described above for the first thermosetting composition.

[0120]

A content ratio of the layered silicate compound in the third thermosetting composition, namely, a content ratio of the layered silicate compound in the sealable resin layer 13 is preferably 1% by mass or more, more preferably 1.2% by mass or more, even more preferably 1.4% by mass or more. Such a configuration is suitable to increase the viscosity of the sealable resin layer 13 and develop the thixotropy of the sealable resin layer 13 that makes the viscosity of the sealable resin layer 13 under pressure lower than the viscosity without pressure. The content ratio of the layered silicate compound in the third thermosetting composition is preferably 6% by mass or less, more preferably 5% by mass or less, even more preferably 4% by mass or less to avoid excessive increase in the viscosity of the third thermosetting composition.

[0121]

Preferably a silicon compound other than the layered silicate compound, even more preferably silica is used as the inorganic filler other than the layered silicate compound in the third thermosetting composition. The inorganic filler may be in, for example, an approximately spherical shape, an approximately planar shape, an approximately aciculate shape, or an amorphous shape. An approximately spherical shape is preferred. An average particle size of the inorganic filler other than the layered silicate compound is in the same range described above for the average particle size of the inorganic filler other than the layered silicate compound in the first thermosetting composition.

[0122]

A content ratio of the inorganic filler other than the layered silicate compound in the third thermosetting composition is preferably 73% by mass or more, more preferably 76% by mass or more, even more preferably 78% by mass or more. Such a configuration is preferable to suppress the expansion and contraction of the sealable resin layer 13 with temperature change. The content ratio is preferably 90% by mass or less, more preferably 85% by mass or less, even more preferably 83% by mass or less. Such a configuration is suitable to avoid excessive increase in the viscosity of the third thermosetting composition and ensure the fluidity of the sealable resin layer 13 in the pressing step described above.

[0123]

A content ratio R3 of the third inorganic filler in the first thermosetting composition, or the sealable resin layer 13, is preferably 75% by mass or more, more preferably 78% by mass or more, even more preferably 80% by mass or more. Such a configuration is preferable to suppress the expansion and contraction of the sealable resin layer 13 with temperature change and achieve an average coefficient of thermal expansion of 20 ppm/°C or less after curing. The content ratio R3 is preferably 90% by mass or less, more preferably 87% by mass or less, even more preferably 85% by mass or less. Such a configuration is suitable to avoid excessive increase in the viscosity of the third thermosetting composition and ensure the fluidity of the sealable resin layer 13 in the pressing step described above.

[0124]

A ratio of the layered silicate compound in the third inorganic filler is preferably 0.5% by mass or more, more preferably 1% by mass or more, even more preferably 1.5% by mass or more. The ratio is preferably 8% by mass or less, more preferably 7% by mass or less, even more preferably 6.5% by mass or less. Such a configuration is suitable to suppress the expansion and contraction of the sealable resin layer 13 with temperature change, ensure the fluidity in the pressing step described above, and develop the above-described thixotropy, while keeping a proper balance between them.

[0125]

The third thermosetting composition may contain another component as described above for the first thermosetting composition.

[0126]

The sealable resin sheet X illustrated in FIG. 3 is produced by, for example, forming each of the sealable resin layers 11, 12, and 13, and then bonding the sealable resin layer 11, the sealable resin layer 13, and the sealable resin layer 12 together in this order. The sealable resin layer 13 is formed by the same method of forming the sealable resin layers 11 and 12 as described above.

[0127]

A ratio of the total thickness of the thickness H1 of the sealable resin layer 11 and a thickness H3 of the sealable resin layer 13 to the entire thickness of the sealable resin sheet X is preferably 0.4 or more, more preferably 0.5 or more, even more preferably 0.6 or more. Such a structure is preferable to suppress the flow of the sealable resin layer 12 into the electronic-component-chip side in the pressing step described above.

[0128]

The ratio of the total thickness of the thickness H1 of the sealable resin layer 11 and the thickness H3 of the sealable resin layer 13 to the entire thickness of the sealable resin sheet X is 0.82 or less, preferably 0.8 or less. Such a structure is suitable to ensure the fluidity of the sealable resin sheet X as a whole and fill the gaps between the adjacent chips with the sealable resin in the pressing step described above.

[0129]

The lowest melt viscosity of the sealable resin layer 13 is preferably 120 kPa·s or more, more preferably 150 kPa·s or more. The lowest melt viscosity of the sealable resin layer 13 is preferably 260 kPa·s or less, more preferably 240 kPa·s or less. Such a configuration is preferable to ensure the fluidity of the sealable resin sheet X as a whole and fill the gaps between the adjacent chips with the sealable resin in the pressing step described above.

[0130]

After being cured by heating at 150°C for one hour, the sealable resin layer 13 has an average coefficient of thermal expansion Z3 of 20 ppm/°C or less in a temperature range from -40°C to the glass transition temperature of the sealable resin layer 13. Such a configuration is suitable to suppress the internal stress in the sealable resin layer 13 of the sealable resin sheet X,

where the sealable resin layer 13 is cooled down to, for example, a room temperature after curing by the high temperature heating.

[Examples]

[0131]

The present invention is described in more detail with reference to Examples. The present invention is not limited to Examples. 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 THE 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").

[0132]

[Production Examples 1 to 8]

Each of the resin films of Production Examples 1 to 8 for forming a sealable resin layer was produced as follows. First, the components of the formulation of Table 1 were blended to prepare a composition that is a varnish. The unit of the numerical values of the compositions in Table 1 is relative "parts by mass". Next, the composition was applied on a polyethylene terephthalate (PET) film having a surface treated with a silicone release coating, thereby forming a coating film. Next, the coating film was dried by heating at 120°C for two minutes, thereby producing a resin film with a thickness of 50 μm in B stage on the PET film. A resin film with a thickness of 40 μm was also produced for Production Example 2. A resin film with a thickness of 40 μm and a resin film with a thickness of 20 μm were also produced for Production Example 5.

[0133]

[Table 1]

	Production Example 1	Production Example 2	Production Example 3	Production Example 4	Production Example 5	Production Example 6	Production Example 7	Production Example 8
Thermosetting resin	Epoxy resin E1 (EXA-4850-150)	—	—	—	—	5.10	—	—
	Epoxy resin E2 (YSLV-80XY)	5.71	5.37	4.79	5.54	5.10	6.70	2.84
	Epoxy resin E3 (EPPN-501HY)	—	—	—	1.39	—	1.68	0.71
	Phenol resin F1 (LVR-8210DL)	0.59	0.56	1.79	3.87	—	4.68	1.98
	Phenol resin F2 (MEHC-7851SS)	—	—	—	—	7.68	—	—
	Phenol resin F3 (TPM-100)	2.37	2.23	2.63	—	—	—	—
Thermoplastic resin	Acrylic polymer (HME-2006M)	10.50	6.18	14.86	4.50	16.55	5.35	2.53
Inorganic filler	Organic bentonite (S-Ben NX)	1.40	1.40	1.75	—	—	—	—
	First silica particles (FB-8SM)	34.02	34.86	34.37	44.77	34.13	43.17	48.50
	Second silica Particles (SC220G-SMJ)	22.68	23.24	22.91	24.11	18.38	23.25	26.11
Curing accelerator	imidazole compound (2PHZ-PW)	0.04	0.04	0.05	0.13	0.08	0.15	0.07
Silane coupling agent	3-glycidoxy propyl trimethoxy silane (KBM-403)	0.85	0.87	0.86	1.03	0.79	1.00	1.12
Pigment	Carbon black#20	0.23	0.20	0.27	0.26	0.44	0.30	0.17
Solvent	Methyl ethyl ketone	21.60	25.06	15.61	14.40	11.76	13.72	15.97
Thickness (μm)		50	50	50	50	50	50	50

[0134]

The components used in Production Examples 1 to 8 are as follows.

Epoxy resin E1: “EPICLON EXA-4850-150” manufactured by DIC (bisphenol A epoxy resin, molecular weight of 900, epoxy equivalent of 450 g/eq, liquid at room temperature)

Epoxy resin E2: “YSLV-80XY” manufactured by the new Nippon Steel Chemical Co., Ltd. (bisphenol F type epoxy resin, high-molecular-weight epoxy resin, epoxy equivalent of 191 g/eq., solid at room temperature, softening point of 80°C) Epoxy resin E3: “EPPN-501HY”

manufactured by Nippon Kayaku Co.,Ltd. (multifunctional epoxy resin, epoxy equivalent of 169 g/eq, solid at room temperature, softening point of 60°C) Phenol resin F1: “LVR- 8210DL”

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

Phenol resin F2: “MEHC-7851SS” manufactured by Meiwa Plastic Industries, Ltd. (phenol aralkyl resin, latent curing agent, hydroxyl group equivalent of 201 to 220 g/eq, solid at room temperature, softening point of 64 to 85°C)

Phenol resin F3: “TPM-100” manufactured by Gunei Chemical Industry Co., Ltd.

(triphenylmethane phenol resin, latent curing agent, hydroxyl group equivalent of 98 g/eq, solid at room temperature, softening point of 108.2°C)

Acryl resin (acrylic polymer): HME-2006M manufactured by Negami Chemical Industrial Co.,Ltd. (a carboxyl group-containing acrylic resin, acid value of 32 mgKOH/g, weight-average molecular weight of 1,290,000, glass-transition temperature (T_g) of -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-glycidoxypolytrimethoxysilane)

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

First silica particles: “FB-8SM” manufactured by Denka Company Limited (spherical silica particles, average particle size of 7.0 μm, without surface treatment)

Second silica particles: They were made of “SC220G-SMJ” manufactured by Admatechs Company Limited (spherical silica particles, average particle size of 0.5 μm) having a surface finished with 3-methacryloxypropyl trimethoxysilane (“KBM- 503” manufactured by Shin-Etsu Chemical Co., Ltd.). (The surface is finished with 1 part by mass of a silane coupling agent with respect to 100 parts by mass of the silica particles.)

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

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

Solvent: methyl ethyl ketone

[0135]

[Examples 1 to 9 and Comparative Examples 1 to 5]

Each of the sealable resin sheets of Examples 1 to 9 and Comparative Examples 1 to 5 was produced, specifically as follows.

[0136]

The sealable resin sheet of Example 1 was produced as follows. Two resin films with a thickness of 50 μm of Production Example 1 were bonded together, thereby forming a first sealable resin layer with a thickness of 100 μm . Three resin films with a thickness of 50 μm of Production Example 5 were bonded together, thereby forming a second sealable resin layer with a thickness of 150 μm . The first and second sealable resin layers were bonded together. The bonding was carried out at 80°C. The same temperature was applied to the bonding described below.

[0137]

The sealable resin sheet of Example 2 was produced as follows. Three resin films with a thickness of 50 μm of Production Example 1 were bonded together, thereby forming a first sealable resin layer with a thickness of 150 μm . Two resin films with a thickness of 50 μm of

Production Example 5 were bonded together, thereby forming a second sealable resin layer with a thickness of 100 μm . The first and second sealable resin layers were bonded together.

[0138]

The sealable resin sheet of Example 3 was produced as follows. Four resin films with a thickness of 50 μm of Production Example 1 were bonded together, thereby forming a first sealable resin layer with a thickness of 200 μm . A resin film with a thickness of 50 μm of Production Example 5 was prepared as a second sealable resin layer. The first and second sealable resin layers were bonded together.

[0139]

The sealable resin sheet of Example 4 was produced as follows. Two resin films with a thickness of 50 μm of Production Example 2 were bonded together, thereby forming a first sealable resin layer with a thickness of 100 μm . Three resin films with a thickness of 50 μm of Production Example 5 were bonded together, thereby forming a second sealable resin layer with a thickness of 150 μm . The first and second sealable resin layers were bonded together.

[0140]

The sealable resin sheet of Example 5 was produced as follows. Three resin films with a thickness of 50 μm of Production Example 2 were bonded together, thereby forming a first sealable resin layer with a thickness of 150 μm . Two resin films with a thickness of 50 μm of Production Example 5 were bonded together, thereby forming a second sealable resin layer with a thickness of 100 μm . The first and second sealable resin layers were bonded together.

[0141]

The sealable resin sheet of Example 6 was produced as follows. Four resin films with a thickness of 50 μm of Production Example 4 were bonded together, thereby forming a first sealable resin layer with a thickness of 200 μm . A resin film with a thickness of 50 μm of Production Example 5 was prepared as a second sealable resin layer. The first and second sealable resin layers were bonded together.

[0142]

The sealable resin sheet of Example 7 was produced as follows. Two resin films with a thickness of 40 μm of Production Example 2 were bonded together, thereby forming a first sealable resin layer with a thickness of 80 μm . Three resin films with a thickness of 40 μm of Production Example 5 were bonded together, thereby forming a second sealable resin layer with a thickness of 120 μm . The first and second sealable resin layers were bonded together.

[0143]

The sealable resin sheet of Example 8 was produced as follows. Three resin films with a thickness of 50 μm of Production Example 2 were bonded together, thereby forming a first sealable resin layer with a thickness of 150 μm . Two resin films with a thickness of 50 μm of Production Example 8 were bonded together, thereby forming a second sealable resin layer with a thickness of 100 μm . The first and second sealable resin layers were bonded together.

[0144]

The sealable resin sheet of Example 9 was produced as follows. Two resin films with a thickness of 50 μm of Production Example 2 were bonded together, thereby forming a first sealable resin layer with a thickness of 100 μm . A resin film of Production Example 1 with a thickness of 50 μm was prepared as a third sealable resin layer. Two resin films with a thickness of 50 μm of Production Example 5 were bonded together, thereby forming a second sealable resin layer with a thickness of 100 μm . The first, third, and second sealable resin layers were bonded together in this order.

[0145]

The sealable resin sheet of Comparative Example 1 was produced as follows. Two resin films with a thickness of 50 μm of Production Example 1 were bonded together, thereby forming a first sealable resin layer with a thickness of 100 μm . A resin film with a thickness of 20 μm of Production Example 5 was prepared as a second sealable resin layer. The first and second sealable resin layers were bonded together.

[0146]

The sealable resin sheet of Comparative Example 2 was produced as follows. Two resin films with a thickness of 40 μm of Production Example 2 were bonded together, thereby forming a first sealable resin layer with a thickness of 80 μm . Four resin films with a thickness of 50 μm of Production Example 5 were bonded together, thereby forming a second sealable resin layer with a thickness of 200 μm . The first and second sealable resin layers were bonded together.

[0147]

The sealable resin sheet of Comparative Example 3 was produced as follows. Two resin films with a thickness of 50 μm of Production Example 3 were bonded together, thereby forming a first sealable resin layer with a thickness of 100 μm . Three resin films with a thickness of 50 μm of Production Example 6 were bonded together, thereby forming a second sealable resin layer with a thickness of 150 μm . The first and second sealable resin layers were bonded together.

[0148]

The sealable resin sheet of Comparative Example 4 was produced as follows. Two resin films with a thickness of 50 μm of Production Example 4 were bonded together, thereby forming a first sealable resin layer with a thickness of 100 μm . Three resin films with a thickness of 50 μm of Production Example 6 were bonded together, thereby forming a second sealable resin layer with a thickness of 150 μm . The first and second sealable resin layers were bonded together.

[0149]

The sealable resin sheet of Comparative Example 5 was produced as follows. Two resin films with a thickness of 50 μm of Production Example 3 were bonded together, thereby forming a first sealable resin layer with a thickness of 100 μm . Three resin films with a thickness of 50 μm of Production Example 7 were bonded together, thereby forming a second

sealable resin layer with a thickness of 150 μm . The first and second sealable resin layers were bonded together.

[0150]

<Lowest Melt Viscosity>

The lowest melt viscosity of the first sealable resin layer of each sealable resin sheet of Examples 1 to 9 and Comparative Examples 1 to 5 was measured as follows.

[0151]

First, 20 resin films, each of which had a thickness of 50 μm and was for forming the first sealable resin layer of each of Examples 1 to 9 and Comparative Examples 1 to 5, were bonded together, and thereby producing a sample film with a thickness of 1 mm for the measurement of the lowest melt viscosity of each of Examples 1 to 9 and Comparative Examples 1 to 5. Next, the viscoelasticity of each sample film was measured. The measurement was carried out with a rheometer, the trade name "HAAKE MARS III" manufactured by Thermo Fisher Scientific. The sample film was held between the heating plate and the parallel plate with a diameter of 8 mm parallel to the heating plate in the rheometer. The gap between the plates was set to 0.8 mm. The viscosity of the sample film was measured under the conditions of a frequency of 1 Hz, a deformation value of 0.005%, a temperature range from 50°C to 90°C, and a rate of temperature increase of 30°C/min. The viscosity at the temperature at which the viscosity became the lowest in the temperature range of the measurement is shown as the lowest melt viscosity ($\text{kPa}\cdot\text{s}$) in Tables 2 to 4.

[0152]

<Average Coefficient of Thermal Expansion>

The average coefficient of thermal expansion of each of the cured sealable resin layers of Examples 1 to 9 and Comparative Examples 1 to 5 was obtained.

[0153]

First, a sheet piece with a width of 4.5 mm and a length of 16 mm was cut out of the sealable resin sheet. Next, the sheet piece was cured by heating at 150°C for one hour. Then, to leave the first, second, or third sealable resin layer, i.e., a target layer of which thermal expansion coefficient was to be measured, each of the cured sealable resin layers other than the target layer was removed from the cured sheet piece by mechanical grinding. The mechanical grinding was carried out with a grinder, the product name “EcoMet 250” manufactured by BUEHLER. Next, the coefficient of linear thermal expansion of the cured sealable resin layer prepared as described above was measured with a thermal mechanical analyzer (TMA) under the following conditions for TMA measurement. From the results of the measurement, the glass transition temperature of the cured sealable resin layer and the average coefficient of thermal expansion in a temperature range from -40°C to the glass transition temperature of the layer were obtained. Average coefficient of thermal expansions Z1, Z2, and Z3 (ppm/°C) of the cured first to third sealable resin layers are shown in Tables 2 to 4.

[0154]

(Measurement Conditions)

Thermal mechanical analyzer (TMA): Q400 TMA, manufactured by TA Instruments Japan Inc.

Mode: tensile mode

Rate of temperature increase: 1°C/min

Modulation: $\pm 5.000^\circ\text{C}/300\text{ sec}$

Measurement temperature range: from -40°C to 260°C

[0155]

<Evaluation on Entry Length>

The hollow encapsulating property of each of the sealable resin sheets of Examples 1 to 9 and Comparative Examples 1 to 5 was evaluated specifically as follows.

[0156]

First, as illustrated in FIG. 4A, a sample sheet X' with a length of 10 mm and a width of 10 mm was prepared from each of the sealable resin sheets of Examples and Comparative Examples. The sample sheets X' cut out of the sealable resin sheets of Examples 1 to 8 and Comparative Examples 1 to 5 each included a first sealable resin layer 11 and a second sealable resin layer 12 sequentially in a thickness direction. A sample sheet X' cut out of the sealable resin sheet of Example 9 included a first sealable resin layer 11, a third sealable resin layer not illustrated, and a second sealable resin layer 12 sequentially in the thickness direction.

[0157]

A dummy chip mounting substrate was prepared as a workpiece W. The dummy chip mounting substrate included a glass substrate S and a plurality of dummy chips 21' (3 mm × 3 mm × a thickness of 250 μm). The dummy chips 21' were bonded to the substrate S via bump electrodes 22 in a state of facing the substrate S through gaps G. The mounting height of the dummy chips 21' was 300 μm. The mounting interval between the dummy chips 21' was 300 μm. The length from the substrate S to the dummy chip 21' in the gap G, i.e., the separate distance between the substrate S and the dummy chip 21' was 50 μm.

[0158]

Next, as illustrated in FIG. 4B, the workpiece W and sample sheet X' were disposed between the first pressing plate P1 and second pressing plate P2 of a plate pressing machine.

[0159]

Next, as illustrated in FIG. 4C, the dummy chips 21' on the substrate S were sealed with the sample sheet X' by vacuum plate pressing under the sealing condition of a temperature of 70°C, a degree of vacuum of 1.6 kPa or less, a pressing force of 0.1 MPa, and a pressing time of 40 seconds (the pressing step).

[0160]

Next, as illustrated in FIG. 4D, the sample sheet X' was cured by heating at 150°C under atmospheric pressure for one hour.

[0161]

Next, as illustrated in the enlarged view of FIG. 4D, the length in which the sealable resin that is a part of the first sealable resin layer 11 of the sample sheet X' entered a gap G between a dummy chip 21' and the substrate S from the side surface 21b was measured as an entry length L (μm) based on the side surface 21b of the dummy chip 21'. The results are shown in Tables 2 to 4. The negative value of the entry length L (μm) means that a space illustrated by the phantom line of FIG. 4D and protruding outward from the side surface 21b of the dummy chip 21' was formed. The absolute value of the negative value corresponds to the protruding length of the space.

[0162]

Each of the sealable resin sheets of Examples 1 to 9 achieved a proper sealing of the dummy chips 21' with an entry length L of 0 μm or more and 50 μm or less.

[0163]

In contrast to Examples, the sealable resin sheet of Comparative Example 1 failed to sufficiently fill the regions between the dummy chips 21' in the pressing step (FIG. 4C). Specifically, a void or an empty space was formed between the substrate S and the sealable resin sheet X' in a region between the dummy chips 21'. A breakage of the first sealable resin layer 11 occurred in the sealable resin sheet of Comparative Example 2 in the pressing step. Thus, a part of the second sealable resin layer 12 flew through the broken part of the first sealable resin layer 11 into the dummy chips 21' side. The flowing resin passed between the dummy chip 21' and the first sealable resin layer 11 to reach a gap G, and consequently excessively entered the gap G. In each of the sealable resin sheets of Comparative Examples 3 and 5, the first sealable resin layer 11 excessively entered a gap G between the substrate S and a dummy chip 21' in the pressing step. The sealable resin sheet of Comparative Example 4 had a poor fluidity and consequently failed to encapsulate the gaps G in the pressing step. The entry length L had a negative value.

[0164]

[Table 2]		Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8
First sealable resin layer		Production Example 1	Production Example 1	Production Example 1	Production Example 2	Production Example 2	Production Example 2	Production Example 2	Production Example 2
Thickness H1 (μm)		100	150	200	100	150	200	80	150
Content ratio R1 of inorganic filler (% by mass)		83	83	83	85	85	85	85	85
Content ratio of layered silicate compound (% by mass)		2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Lowest melt viscosity (kPa·s)		160	160	160	240	240	240	240	240
Average coefficient of thermal expansion Z1 (ppm/°C)		17	17	17	13	13	13	13	13
Second sealable resin layer		Production Example 5	Production Example 5	Production Example 5	Production Example 5	Production Example 5	Production Example 5	Production Example 5	Production Example 8
Thickness H2 (μm)		150	100	50	150	100	50	120	100
Content ratio R2 of inorganic filler (% by mass)		84	84	84	84	84	84	84	91
Average coefficient of thermal expansion Z2 (ppm/°C)		10	10	10	10	10	10	10	10
H1 / Total thickness		0.40	0.60	0.80	0.40	0.60	0.80	0.40	0.60
Entry length L (μm)		48	33	17	42	29	13	5	15

[0165]

[Table 3]

	Example 9
First sealable resin layer	Production Example 2
Thickness H1 (μm)	100
Content ratio R1 of inorganic filler (% by mass)	85
Content ratio of layered silicate compound (% by mass)	2.0
Lowest melt viscosity ($\text{kPa} \cdot \text{s}$)	240
Average coefficient of thermal expansion Z1 ($\text{ppm}/^{\circ}\text{C}$)	13
Third sealable resin layer	Production Example 1
Thickness H3 (μm)	50
Content ratio R3 of inorganic filler (% by mass)	83
Content ratio of layered silicate compound (% by mass)	2.0
Average coefficient of thermal expansion Z3 ($\text{ppm}/^{\circ}\text{C}$)	17
Second sealable resin layer	Production Example 5
Thickness H2 (μm)	100
Content ratio R2 of inorganic filler (% by mass)	84
Average coefficient of thermal expansion Z2 ($\text{ppm}/^{\circ}\text{C}$)	10
H1 / Total thickness	0.40
(H1 + H3) / Total thickness	0.60
Entry length L (μm)	32

[0166]

[Table 4]

	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4	Comparative Example 5
First sealable resin layer	Production Example 1	Production Example 2	Production Example 3	Production Example 4	Production Example 3
Thickness H1 (μm)	100	80	100	100	100
Content ratio R1 of inorganic filler (% by mass)	83	85	81	86	81
Content ratio of layered silicate compound (% by mass)	2.0	2.0	2.0	2.5	2.0
Lowest melt viscosity (kPa·s)	160	240	100	360	100
Average coefficient of thermal expansion Z1 (ppm/°C)	17	13	22	14	22
Second sealable resin layer	Production Example 5	Production Example 5	Production Example 6	Production Example 6	Production Example 7
Thickness H2 (μm)	20	200	150	150	150
Content ratio R2 of inorganic filler (% by mass)	84	84	70	70	81
Average coefficient of thermal expansion Z2 (ppm/°C)	10	10	42	42	17
H1 / Total thickness	0.83	0.29	0.40	0.40	0.40
Entry length L (μm)	—	100	80	-100	85

Description of Reference Numerals

[0167]

X sealable resin sheet

D thickness direction

11 sealable resin layer (first sealable resin layer)

12 sealable resin layer (second sealable resin layer)

13 sealable resin layer (third sealable resin layer)

W workpiece

S substrate

Sa mounting surface

21 chip

21a principal surface

21b side surface

22 bump electrode

P1 first pressing plate

P2 second pressing plate

CLAIMS

1. A sealable resin sheet comprising:

a first sealable resin layer and a second sealable resin layer sequentially in a thickness direction, wherein

the first sealable resin layer contains a first thermosetting resin and a first inorganic filler, and has, after curing, an average coefficient of thermal expansion of 20 ppm/°C or less in a temperature range from -40°C to a glass transition temperature of the first sealable resin layer,

the second sealable resin layer contains a second thermosetting resin and a second inorganic filler, and has, after curing, an average coefficient of thermal expansion of 20 ppm/°C or less in a temperature range from -40°C to a glass transition temperature of the second sealable resin layer,

a content ratio of the first inorganic filler in the first sealable resin layer differs from a content ratio of the second inorganic filler in the second sealable resin layer, and

a ratio of a thickness of the first sealable resin layer to an entire thickness of the sealable resin sheet is 0.37 or more and 0.82 or less.

2. The sealable resin sheet according to claim 1, wherein the first sealable resin layer has a thickness of 90 μm or more.

3. The sealable resin sheet according to claim 1 or 2, wherein the first sealable resin layer has the lowest melt viscosity of 120 kPa·s or more.

4. The sealable resin sheet according to any one of claims 1 to 3, wherein the first sealable resin layer has the lowest melt viscosity of 260 kPa·s or less.

5. The sealable resin sheet according to any one of claims 1 to 4, further comprising:

a third sealable resin layer between the first sealable resin layer and the second sealable resin layer, wherein

the third sealable resin layer contains a third thermosetting resin and a third inorganic filler, and has, after curing, an average coefficient of thermal expansion of 20 ppm/°C or less in a temperature range from -40°C to a glass transition temperature of the third sealable resin layer.

6. The sealable resin sheet according to any one of claims 1 to 5, wherein

the third sealable resin layer is in direct contact with the first sealable resin layer, and a ratio of a total thickness of a thickness of the first sealable resin layer and a thickness of the third sealable resin layer to an entire thickness of the sealable resin sheet is 0.4 or more and 0.82 or less.

7. The sealable resin sheet according to any one of claims 1 to 6, wherein

the content ratio of the inorganic filler in each of the sealable resin layers is 75% by mass or more.

8. The sealable resin sheet according to any one of claims 1 to 7, wherein

the content ratio of the inorganic filler in each of the sealable resin layers is 90% by mass or less.

9. An electronic component device comprising:

a base material;

an electronic component chip mounted on the base material in a state in which the electronic component chip faces the base material through a gap; and

a cured resin portion formed of the sealable resin sheet according to any one of claims 1 to 8, the cured resin portion encapsulating the electronic component chip and the gap.