

DESCRIPTION

TITLE OF THE INVENTION: SEALING RESIN SHEET FOR SUBSTRATE HAVING ELECTRONIC COMPONENT BUILT THEREIN AND METHOD FOR MANUFACTURING SUBSTRATE HAVING ELECTRONIC COMPONENT BUILT THEREIN

TECHNICAL FIELD

[0001]

The present invention relates to a sealing resin sheet for a substrate having an electronic component built therein and a method for manufacturing the substrate having an electronic component built therein.

BACKGROUND ART

[0002]

Today, along with the spread of mobile devices such as cellular phones, the degree of demands for miniaturization and high performance of circuit boards used for electronic devices is increasing. In order to cope with such demands, an improvement in packaging density of an electronic component in a multilayer printed wiring board or the like has been attempted. The miniaturization of an electronic component itself and the microfabrication of a wiring or the like have been promoted.

[0003]

An insulating layer or the like of a multilayer printed wiring board is required to have an embedding property capable

of filling a fine electronic component and wiring. As a resin composition when such performance is considered, a resin composition for a printed wiring board containing a cyanate ester resin, an epoxy resin, a thermoplastic resin, talc, and silica has been proposed (see Patent Document 1).

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0004]

Patent Document 1: JP-A-2010-202865

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0005]

Meanwhile, as measures for improving packaging density of an electronic component, the miniaturization of an electronic component itself, the microfabrication of a wiring or the like, as well as the arrangement of an electronic component have been devised. For example, a technique for a substrate having an electronic component built therein has been developed. The technique embeds an electronic component which has been heretofore mounted on a surface of a substrate to be built in a substrate (within a range in a thickness direction) using a sealing resin. The electronic component is built in the substrate, which not only makes it possible to achieve high

density and low profile but also provides the expectations of reduction in noise and an improvement in heat radiation performance if the electronic component is built in a copper substrate, for example.

[0006]

Not only a smart phone, a PC, and a tablet terminal but also a consumer device (an air conditioner or the like) and a high power device for automobile use have been also studied as applications of the technique for a substrate having an electronic component built therein. Therefore, the thickness of a substrate varies from several tens of microns to several hundreds of microns depending on built-in electronic components.

[0007]

It is also necessary to form a sealing resin sheet for embedding an electronic component so as to be capable of coping with the thickness of a substrate, and a thick sealing resin sheet has been particularly required. In a coating method which is a representative production method for a sealing resin sheet, it is necessary that a raw material mixture containing a solvent is applied in a sheet form to obtain a coated product, and the solvent is removed during drying to bring the coated product into a semi-cured state. The vicinity of a surface of a thick sheet is dried first, which may cause the internal solvent to remain without sufficient dissipation of the solvent. When a

sealing resin sheet in which a solvent remains is used in a manufacturing process for a substrate having an electronic component built therein, foaming occurs (a void occurs) in the sealing resin sheet, which may cause deterioration in quality.

[0008]

Therefore, it may also be one measure to produce a sealing resin sheet having an intended thickness by laminating thin sealing resin sheets formed by a coating method or drying and solidifying a coating film formed in multiple stages. However, in the lamination of sealing resin sheets or multistage coating, it is difficult to sufficiently suppress the biting of voids between layers, which nevertheless may cause deterioration in quality.

[0009]

When the content of an inorganic filler is high, the tackiness between layers is deteriorated, so that voids as described above tend to more remarkably occur. A reduction in the content of the inorganic filler can contribute to the suppression of voids. However, the reduction makes it difficult to control the linear expansion coefficient of a sealing resin sheet after being cured, which causes the mismatching of the linear expansion coefficient of the sealing resin sheet with that of a substrate such as a copper substrate, so that the warpage of the obtained substrate having an electronic component built therein may occur.

[0010]

An object of the present invention is to provide a sealing resin sheet for a substrate having an electronic component built therein, which has an easily controllable linear expansion coefficient and can suppress the occurrence of voids during its production, and a method for manufacturing a substrate having an electronic component built therein using the sealing resin sheet.

MEANS FOR SOLVING THE PROBLEMS

[0011]

The present inventors have extensively conducted studies, and resultantly found that the above-mentioned object can be achieved by employing the configuration described below. This finding has led to the completion of the present invention.

[0012]

That is, the present invention relates to a sealing resin sheet for a substrate having an electronic component built therein, the sealing resin sheet having a single layer structure having a thickness of 150 μm or more and 1000 μm or less, and the sealing resin sheet having a linear expansion coefficient of 10 ppm/K or more and 28 ppm/K or less after a heat treatment at 150°C for 1 hour.

[0013]

The sealing resin sheet for a substrate having an

electronic component built therein (hereinafter also simply referred to as a "sealing resin sheet") has a thickness of 150 μm or more and 1000 μm or less, so that one sealing resin sheet can cope with substrates having various thicknesses. In particular, the sealing resin sheet can suitably cope with a thick substrate that is difficult to be handled by a resin sheet obtained by a coating method. The linear expansion coefficient after the heat treatment at 150°C for 1 hour (hereinafter also simply referred to as a "linear expansion coefficient") is 10 ppm/K or more and 28 ppm/K or less, so that the matching of the linear expansion coefficient of the sealing resin sheet with that of a substrate (particularly, copper substrate) can be achieved, and the warpage of the substrate having an electronic component built therein can be suppressed.

[0014]

The sealing resin sheet for a substrate having an electronic component built therein preferably includes an inorganic filler having an average particle diameter of 0.5 μm to 5 μm , and

a content of the inorganic filler is preferably 70 to 87% by weight.

[0015]

In a substrate having an electronic component built therein obtained by using the sealing resin sheet, a via may be formed in the sealing resin sheet portion in order to achieve

conduction between the embedded electronic component and the outside. Smoothness is required for an inner wall of the via in consideration of ease of plating. By setting the average particle diameter of the inorganic filler included in the sealing resin sheet to a minute size of 0.5 μm to 5 μm , the smoothness of the inner wall of the via can be achieved even when the via is formed in the sealing resin sheet portion.

[0016]

Furthermore, the linear expansion coefficient after thermal curing can be more easily controlled by setting the content of the inorganic filler in the sealing resin sheet to 70 to 87% by weight.

[0017]

The sealing resin sheet for a substrate having an electronic component built therein preferably has a minimum melt viscosity of 1 Pa·s or more and 200 Pa·s or less in a temperature range of 50°C to 200°C. This makes the fluidity of the sealing resin sheet favorable when the substrate is sealed, and this makes it possible to improve the embedding properties of an opening portion of the substrate and the electronic component.

[0018]

The sealing resin sheet for a substrate having an electronic component built therein is preferably formed by kneading extrusion. This makes it possible to produce a thick

sealing resin sheet having no void efficiently while the content of the inorganic filler is increased.

[0019]

The present invention also relates to a method for manufacturing a substrate having an electronic component built therein, the method including the steps of:

disposing at least one electronic component in an opening portion formed in a substrate;

disposing the sealing resin sheet for a substrate having an electronic component built therein on a substrate so as to cover the opening portion;

heating and pressing the sealing resin sheet for a substrate having an electronic component built therein from an upper surface side of the sealing resin sheet, to fill the opening portion of the substrate with the sealing resin sheet; and

thermally curing the sealing resin sheet for a substrate having an electronic component built therein.

[0020]

The manufacturing method makes it possible to efficiently manufacture a highly-reliable substrate having an electronic component built therein that suppresses both voids and warpage.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021]

Fig. 1A is a view schematically showing one step of a method for manufacturing a substrate having an electronic component built therein according to one embodiment of the present invention.

Fig. 1B is a view schematically showing one step of the method for manufacturing a substrate having an electronic component built therein according to one embodiment of the present invention.

Fig. 1C is a view schematically showing one step of the method for manufacturing a substrate having an electronic component built therein according to one embodiment of the present invention.

Fig. 1D is a view schematically showing one step of the method for manufacturing a substrate having an electronic component built therein according to one embodiment of the present invention.

Fig. 1E is a view schematically showing one step of the method for manufacturing a substrate having an electronic component built therein according to one embodiment of the present invention.

Fig. 1F is a view schematically showing one step of the method for manufacturing a substrate having an electronic component built therein according to one embodiment of the present invention.

MODE FOR CARRYING OUT THE INVENTION

[0022]

Hereinafter, a sealing resin sheet for a substrate having an electronic component built therein according to one embodiment of the present invention will be described with reference to the drawings. However, in part or all of the drawings, parts unnecessary for explanation are omitted, and there are parts shown by magnification or reduction in order to facilitate explanation.

[0023]

<<Sealing Resin Sheet for Substrate Having Electronic Component Built Therein>>

A sealing resin sheet 3 for a substrate having an electronic component built therein (see Fig. 1D) according to one embodiment of the present invention is a sheet-shaped product having a certain thickness, and its planar view shape can be appropriately selected according to a substrate shape such as a circular shape, a rectangular shape, or a square shape. The sealing resin sheet 3 is typically provided in a state where it is laminated on a support (not shown) such as a polyethylene terephthalate (PET) film. The support may be subjected to a mold release treatment in order to easily peel off the sealing resin sheet 3.

[0024]

The sealing resin sheet 3 has a single layer structure,

and a thickness of the sealing resin sheet 3 is preferably 150 μm or more, more preferably 200 μm or more, and still more preferably 250 μm or more. The thickness of the sealing resin sheet 3 is preferably 1000 μm or less, more preferably 800 μm or less, and still more preferably 600 μm or less. When the thickness falls within the above range, the sealing resin sheet 3 can cope with the sealing of substrates having various thicknesses.

[0025]

A linear expansion coefficient of the sealing resin sheet 3 after being subjected to a heat treatment at 150°C for 1 hour is preferably 10 ppm/K or more and 28 ppm/K or less, more preferably 12 ppm/K or more and 25 ppm/K or less, and still more preferably 14 ppm/K or more and 23 ppm/K or less. By setting the linear expansion coefficient within the above range, the linear expansion coefficient of the sealing resin sheet 3 can be matched with that of a substrate typified by a copper substrate, so that the warpage of the obtained substrate having an electronic component built therein can be suppressed.

[0026]

A minimum melt viscosity of the sealing resin sheet 3 in a temperature range of 50°C to 200°C is not particularly limited, but it is preferably 1 Pa·s or more and 200 Pa·s or less, more preferably 2 Pa·s or more and 190 Pa·s or less, and still more preferably 3 Pa·s or more and 180 Pa·s or less. By setting the

minimum melt viscosity of the sealing resin sheet 3 within the above range, the filling property (embedding property) of the sealing resin sheet 3 to an opening portion of a substrate can be improved to suppress the occurrence of voids, so that a highly-reliable substrate having an electronic component built therein can be obtained. A too high minimum melt viscosity may cause deterioration in the embedding property of the sealing resin sheet 3 to an opening portion of a substrate. On the other hand, a too low minimum melt viscosity may make it difficult to maintain the shape of the sheet, or may cause flowing of the resin.

[0027]

The sealing resin sheet 3 preferably includes an epoxy resin and a phenol resin. This provides a good thermal curing property.

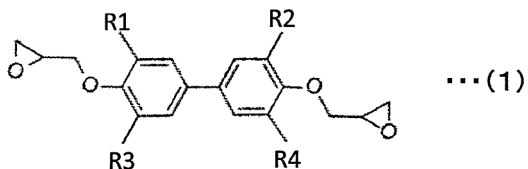
[0028]

The epoxy resin is not particularly limited. Examples of the epoxy resin capable of being used include various kinds of epoxy resins such as a triphenylmethane type epoxy resin, a cresol novolak type epoxy resin, a biphenyl type epoxy resin, a modified bisphenol A type epoxy resin, a bisphenol A type epoxy resin, a bisphenol F type epoxy resin, a modified bisphenol F type epoxy resin, a dicyclopentadiene type epoxy resin, a phenol novolak type epoxy resin, and a phenoxy resin. These epoxy resins may be used alone or in combination of two or more thereof.

[0029]

From the viewpoint of ensuring the toughness of the epoxy resin after being cured and the reactivity of the epoxy resin, an epoxy resin is preferable, which has an epoxy equivalent of 150 to 250 and is solid, at room temperature, having a softening point or melting point of 50 to 130°C. From the viewpoint of reliability, a triphenylmethane type epoxy resin, a cresol novolak type epoxy resin, and a biphenyl type epoxy resin are more preferable. Among these, a biphenyl type epoxy resin is preferable, and a biphenyl type epoxy resin containing an epoxy resin represented by the following chemical formula (1) is particularly preferable:

[Chemical Formula 1]



wherein, R1 to R4 are each independently hydrogen or a methyl group; except the case where all of R1 to R4 are hydrogen.

[0030]

Among organic components, there are compounds which have low crystallinity, and do not return to a crystalline state before melting even if the compounds are once thermally melted and then cooled, resulting in a lower crystalline state. An organic component having low crystallinity may increase the

linear expansion coefficient to cause the warpage of a substrate having an electronic component built therein. The epoxy resin represented by the chemical formula (1) above as the organic component maintains its crystallinity even after thermal melting, so that an increase in the linear expansion coefficient can be suppressed and the warpage of the substrate can be prevented.

[0031]

The sealing resin sheet includes preferably 3 to 10% by weight, more preferably 4 to 9% by weight of the epoxy resin represented by the chemical formula (1) based on the total solid content of the sealing resin sheet. By setting the content of the crystalline epoxy resin within the above range, a warpage preventing property and resin fluidity can be exhibited at a higher level.

[0032]

In the sealing resin sheet, all of R1 to R4 in the chemical formula (1) are preferably methyl groups. This increases the rigidity of the skeleton of the crystalline epoxy resin and also increases the crystallinity, which can more effectively prevent an increase in the linear expansion coefficient.

[0033]

The phenol resin is not particularly limited as long as it provides a curing reaction between the phenol resin and the epoxy resin. For example, a phenol novolak resin, a phenol

aralkyl resin, a biphenyl aralkyl resin, a dicyclopentadiene type phenol resin, a cresol novolac resin, a resole resin and the like are used. These phenol resins may be used alone or in combination of two or more thereof.

[0034]

From the viewpoint of reactivity between the phenol resin and the epoxy resin, a phenol resin having a hydroxyl group equivalent of 70 to 250 and a softening point of 50 to 110°C is preferably used. Among these, from the viewpoint of high curing reactivity, a phenol novolac resin can be suitably used. From the viewpoint of reliability, low moisture-absorption materials such as a phenol aralkyl resin and a biphenyl aralkyl resin can also be suitably used.

[0035]

From the viewpoint of curing reactivity, a blending ratio of the epoxy resin and the phenol resin is preferably such that the total of the hydroxy group in the phenol resin is 0.7 to 1.5 equivalents, and more preferably 0.9 to 1.2 equivalents, based on 1 equivalent of the epoxy group in the epoxy resin.

[0036]

A lower limit of the total content of the epoxy resin and phenol resin in the sealing resin sheet is preferably 9% by weight or more, and more preferably 10% by weight or more. When the total content is 9% by weight or more, a good adhering force to electronic devices, substrates or the like is obtained. On

the other hand, an upper limit of the total content is preferably 28% by weight or less, and more preferably 27% by weight or less. When the total content is 28% by weight or less, the moisture absorbability of the sealing resin sheet can be reduced.

[0037]

From the viewpoint of heat resistance, flexibility, strength or the like, the sealing resin sheet 3 may include a thermoplastic resin. The thermoplastic resin preferably has solvent resistance.

[0038]

Examples of the thermoplastic resin include natural rubber, butyl rubber, isoprene rubber, chloroprene rubber, an ethylene-vinyl acetate copolymer, an ethylene-acrylic acid copolymer, an ethylene-acrylic acid ester copolymer, a polybutadiene resin, a polycarbonate resin, a thermoplastic polyimide resin, polyamide resins such as 6-nylon and 6,6-nylon, a phenoxy resin, an acrylic resin, saturated polyester resins such as PET and PBT, a polyamideimide resin, a fluororesin, a styrene-isobutylene-styrene block copolymer, silicone rubber, and silicone resin. These thermoplastic resins may be used alone or in combination of two or more thereof. Among these, silicone rubber, silicone resin, and a styrene-isobutylene-styrene block copolymer are preferable from the viewpoint of the low stress property, low water absorption property, and solvent resistance of the sealing

resin sheet.

[0039]

When the sealing resin sheet includes the thermoplastic resin, the content of the thermoplastic resin is preferably 1% by weight or more, and more preferably 3% by weight or more. When the content is 1% by weight or more, plasticity and flexibility can be suitably imparted to the sealing resin sheet. The content of the thermoplastic resin in the sealing resin sheet 3 is preferably % by weight or less, and more preferably 14% by weight or less. When the content is 13% by weight or less, the adhesion of the sealing resin sheet to electronic devices or substrates can be improved.

[0040]

The sealing resin sheet preferably includes an inorganic filler. A shape of the inorganic filler is not particularly limited, and may be any shape such as a spherical shape (including an ellipsoid shape), a polyhedral shape, a polygonal column shape, or an irregular shape. From the viewpoint of achievement of a high filling state in the vicinity of a hollow structure and moderate fluidity, a spherical shape is preferable.

[0041]

The inorganic filler is not particularly limited, and various kinds of conventionally known fillers can be used. Examples thereof include powders of quartz glass, talc, silica

(such as molten silica and crystalline silica), alumina, aluminum nitride, silicon nitride, and boron nitride. These inorganic fillers may be used alone or in combination of two or more thereof. Among these, silica and alumina are preferable, and silica is more preferable because the linear expansion coefficient can be satisfactorily reduced.

[0042]

As silica, a silica powder is preferable, and a molten silica powder is more preferable. Examples of the molten silica powder include a spherical molten silica powder and a crushed molten silica powder, but a spherical molten silica powder is preferable from the viewpoint of fluidity.

[0043]

An average particle diameter of the inorganic filler is preferably within a range of 0.5 to 5 μm . By setting the average particle diameter of the inorganic filler within the above range, the smoothness of the inner wall of the via formed in the substrate can be improved.

[0044]

The sealing resin sheet includes preferably 70 to 87% by weight, more preferably 72 to 86% by weight of the inorganic filler based on the total solid content of the sealing resin sheet. By setting the content of the inorganic filler within the above range, the linear expansion coefficient and the minimum melt viscosity can be easily controlled.

[0045]

The sealing resin sheet 3 preferably includes a curing accelerator.

[0046]

The curing accelerator is not particularly limited as long as it promotes curing of the epoxy resin and the phenol resin. Examples of the curing accelerator include organophosphorus compounds such as triphenylphosphine and tetraphenylphosphonium tetraphenylborate; and imidazole compounds such as 2-phenyl-4,5-dihydroxymethylimidazole and 2-phenyl-4-methyl-5-hydroxymethylimidazole. Among these, 2-phenyl-4,5-dihydroxymethylimidazole is preferable, because the curing reaction does not rapidly proceed even when the temperature increases during kneading and the sealing resin sheet 3 can be satisfactorily produced.

[0047]

The content of the curing accelerator is preferably 0.1 to 5 parts by weight based on 100 parts by weight in total of the epoxy resin and the phenol resin.

[0048]

The sealing resin sheet 3 preferably includes a flame retardant component. This makes it possible to reduce expansion of combustion when the sealing resin sheet 3 catches fire due to short circuit or heat generation of the parts. As the flame retardant component, various metal hydroxides such

as aluminum hydroxide, magnesium hydroxide, iron hydroxide, calcium hydroxide, tin hydroxide, and composite metal hydroxide; a phosphazene flame retardant or the like may be used.

[0049]

The sealing resin sheet 3 preferably includes a silane coupling agent. The silane coupling agent is not particularly limited, and examples thereof include 3-glycidoxypopyl trimethoxysilane.

[0050]

A content of the silane coupling agent in the sealing resin sheet 3 is preferably 0.1 to 3% by weight. When the content is 0.1% by weight or more, the strength of the sealing resin sheet after being cured can be increased, and the water absorption rate of the sealing resin sheet can be reduced. On the other hand, when the content is 3% by weight or less, the occurrence of outgas can be suppressed.

[0051]

The sealing resin sheet 3 preferably includes a pigment. The pigment is not particularly limited, and examples thereof include carbon black.

[0052]

A content of the pigment in the sealing resin sheet 3 is preferably 0.1 to 2% by weight. When the content is 0.1% by weight or more, a good marking property is obtained. On the

other hand, when the content is 2% by weight or less, the strength of the sealing resin sheet after being cured can be secured.

[0053]

Besides the above-mentioned respective components, other additives may be appropriately blended into the resin composition, if necessary.

[0054]

<<Method for Manufacturing Sealing Resin Sheet for Substrate Having Electronic Component Built Therein>>

A method for manufacturing the sealing resin sheet 3 for a substrate having an electronic component built therein is not particularly limited, but the method preferably includes preparing a kneaded product and processing the obtained kneaded product into a sheet. Specifically, the above-mentioned respective components are melt-kneaded by a known kneader such as a mixing roll, a pressure kneader, or an extruder to prepare a kneaded product, and the obtained kneaded product is processed into a sheet. As kneading conditions, a temperature is preferably equal to or higher than the softening point of each of the above-mentioned components, and is, for example, 30 to 150°C. When the thermal curing property of the epoxy resin is considered, the temperature is preferably 40 to 140°C, and more preferably 60 to 120°C. A time is, for example, 1 to 30 minutes, and preferably 5 to 15 minutes.

[0055]

The kneading is preferably performed under a reduced pressure condition (under reduced pressure atmosphere). An upper limit of the pressure under the reduced pressure condition is preferably 0.1 kg/cm^2 or less, and more preferably 0.05 kg/cm^2 or less. A lower limit of the pressure under the reduced pressure condition is preferably as low as possible, but it may be $1 \times 10^{-4} \text{ kg/cm}^2$ or more from the viewpoint of productivity and physical limitation. This makes it possible to prevent mixing of gas into the kneaded product, and to suppress occurrence of pores in the obtained kneaded product.

[0056]

The kneaded product after melt-kneading is preferably processed while it is in a high temperature state without being cooled. The processing method is not particularly limited, and examples thereof include a flat plate press method, a T die extrusion method, a roll rolling method, a roll kneading method, an inflation extrusion method, a coextrusion method, and a calender molding method. A processing temperature is preferably equal to or higher than the softening point of each of the above components, and is, for example, 40 to 150°C , preferably 50 to 140°C , and more preferably 70 to 120°C when the thermal curing property and moldability of the epoxy resin are considered.

[0057]

<<Method for Manufacturing Substrate Having Electronic

Component Built Therein>>

Figs. 1A to 1F are views schematically showing one step of a method for manufacturing a substrate having an electronic component built therein according to one embodiment of the present invention. A procedure for manufacturing a substrate having an electronic component built therein is not particularly limited, and the following procedure can be suitably adopted: at least one electronic component 2 is disposed in an opening portion O formed in a substrate 1; a sealing resin sheet 3 is disposed on the substrate 1 so as to cover the opening portion O; the sealing resin sheet 3 is heated and pressed from an upper surface side of the sealing resin sheet 3 to cause the sealing resin sheet 3 to flow, thereby filling the opening portion O of the substrate 1 with the sealing resin sheet 3; and the sealing resin sheet 3 is thermally cured. If necessary, a via 4 may be formed in order to achieve conduction between the electronic component 2 and the outside.

[0058]

(Substrate Preparing Step)

The substrate 1 (see Fig. 1A) is not particularly limited, and examples thereof include a metal substrate such as a copper substrate, a (multilayer) printed wiring substrate, a ceramic substrate, and a silicon substrate.

[0059]

(Opening Portion Forming Step)

Next, the opening portion O is formed in the substrate 1 (see Fig. 1B). The method for forming the opening portion O is not particularly limited, and examples thereof include etching, laser processing, and punching processing. The number of the opening portions to be formed in one substrate is not also particularly limited, and may be appropriately changed according to the intended design of the substrate having an electronic component built therein.

[0060]

(Electronic Component Disposing Step)

As shown in Fig. 1C, at least one electronic component 2 is disposed in the opening portion O formed in the substrate 1. The electronic component is not limited at all. Any electronic component such as a semiconductor chip, a capacitor, a sensor device, a light emitting element, or a vibration element can be used. In Fig. 1C, one electronic component 2 is disposed in one opening portion O, but the number of the electronic components to be disposed in one opening portion is not limited to one, and may be appropriately changed according to the intended design of the substrate having an electronic component built therein.

[0061]

(Filling Step)

In the filling step, as shown in Figs. 1D and 1E, the sealing resin sheet 3 is laminated on the substrate 1 so as to

cover the opening portion 0, and the sealing resin sheet 3 is then heated and pressed from the upper surface side of the sealing resin sheet 3 to cause the sealing resin sheet 3 to flow, thereby filling the opening portion 0 of the substrate 1 with the sealing resin sheet 3, and the sealing resin sheet 3 is then thermally cured.

[0062]

As conditions for heating and pressing the sealing resin sheet 3 to fill the opening portion 0, a temperature is, for example, 80 to 180°C, and preferably 90 to 170°C; a pressure is, for example, 0.1 to 10 MPa, and preferably 0.3 to 8 MPa; and a time is, for example, 5 to 60 minutes, and preferably 10 to 30 minutes. When improvements in the tackiness and followability of the sealing resin sheet 3 to an inner wall of the opening portion 0 and the electronic component 2 are considered, the pressing is preferably performed under a reduced pressure condition (for example, 90 to 100 kPa).

[0063]

After embedding of the opening portion is completed, the sealing resin sheet 3 is subjected to a thermal curing treatment. As conditions for the thermal curing treatment, a heating temperature is preferably 120°C or higher, and more preferably 130°C or higher. On the other hand, an upper limit of the heating temperature is preferably 200°C or less, and more preferably 190°C or less. A heating time is preferably 30 minutes or more,

and more preferably 60 minutes or more. On the other hand, an upper limit of the heating time is preferably 300 minutes or less, and more preferably 180 minutes or less. A pressure may be applied if necessary; and the pressure is preferably 0.1 MPa or more, and more preferably 0.3 MPa or more. On the other hand, an upper limit of the pressure is preferably 10 MPa or less, and more preferably 8 MPa or less. This provides a substrate 10 having an electronic component built therein in which the electronic component 2 is embedded in the substrate 1.

[0064]

(Via Forming Step)

For conduction between the electronic component 2 and the outside, a via hole can be formed in the sealing resin sheet 3, after being cured, by laser irradiation or the like, and a metal material such as copper can be embedded in the via hole to form the via 4. As the formation method and the metal material, conventionally known methods can be appropriately adopted according to the intended design of the substrate having an electronic component built therein.

EXAMPLES

[0065]

Hereinafter, preferred examples of the present invention will be demonstratively described in detail. However, regarding materials, blend amounts and the like described in

examples are not intended to limit the scope of the present invention only to these unless there is a particularly limited description.

[0066]

Components used in examples will be described.

Epoxy resin 1: YX4000H (biphenyl type epoxy resin, epoxy equivalent: 190 g/eq.) manufactured by Mitsubishi Chemical Corporation

Epoxy resin 2: YSLV-80 XY (bisphenol F type epoxy resin, epoxy equivalent: 200 g/eq.) manufactured by Nippon Steel Chemical Co., Ltd.

Epoxy resin 3: Epikote 828 (epoxy equivalent: 190 g/eq.) manufactured by Mitsubishi Chemical Corporation

Phenol resin: MEH-7500-3S (hydroxyl group equivalent: 103 g/eq.) manufactured by Meiwa Plastic Industries, Ltd.

Thermoplastic resin: EP-2601 (silicone elastomer powder) manufactured by Dow Corning Toray Co., Ltd.

Inorganic filler 1: SO-25R (molten spherical silica, average particle diameter 0.5 μm) manufactured by Admatechs Company Limited

Inorganic filler 2: FB-5SDC (molten spherical silica, average particle diameter 5 μm) manufactured by Denka Company Limited

Inorganic filler 3: FB-9454FC (molten spherical silica, average particle diameter 17 μm) manufactured by Denka Company

Limited

Carbon black: #20 manufactured by Mitsubishi Chemical Corporation

Curing accelerator: 2PHZ-PW
(2-phenyl-4,5-dihydroxymethylimidazole) manufactured by Shikoku Chemicals Corporation

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

[0067]

[Examples 1 to 7 and Comparative Examples 2 to 4]

In accordance with blending ratios described in Table 1, respective components were blended to obtain a blended product, and the blended product was melted and kneaded through a roll kneader at 60 to 120°C under a reduced pressure (0.01 kg/cm²) for 10 minutes to prepare a kneaded product. Next, the obtained kneaded product was formed into a sheet by a flat plate press method to produce a sealing resin sheet having a thickness of 500 μm.

[0068]

[Comparative Example 1]

Respective components were added to methyl ethyl ketone at blending ratios shown in Table 1 so that the solid content concentration was set to 93%, and the mixture was stirred for 25 minutes with "MAZERUSTAR" manufactured by KURABO INDUSTRIES

LTD. to prepare a varnish. A polyethylene terephthalate film subjected to a mold release treatment and having a thickness of 50 μm was coated with the obtained varnish, followed by drying at 130°C for 2 minutes to produce a resin sheet having a thickness of 50 μm . Thereafter, the resin sheet having a thickness of 50 μm was laminated with a laminator to obtain a sealing resin sheet having a thickness of 500 μm .

[0069]

<Evaluation>

Regarding the produced sealing resin sheet, the following items were evaluated. The results are shown in Table 1.

[0070]

(Content of Inorganic Filler)

In a platinum container was placed 10 mg of a sample, and a temperature was increased to 1000°C at a rate of 10°C /minute with a device name "TG/DTA 220" (manufactured by SII NanoTechnology Inc.) to sublime an organic substance at an ignition temperature. The content of the inorganic filler was calculated based on the weight of the remaining inorganic filler.

[0071]

(Linear Expansion Coefficient)

A sealing resin sheet subjected to a heat treatment at 150°C for 1 hour was punched out into a circular size having a diameter of 7 mm to prepare a measurement sample. Using a

TMA Q400 (manufactured by TA Instruments Inc.), the measurement sample was sandwiched between a circular probe having a diameter of 5 mm and a stage. In a modulation mode, the measurement sample was measured under conditions of a load of 0.012 N at a temperature range of -20°C to 300°C and a temperature increase rate of 0.5°C /minute. A linear expansion coefficient (CTE1) at 25°C to 80°C and a linear expansion coefficient (CTE2) at 200°C to 260°C were measured. The linear expansion coefficient (CTE1) was taken as the linear expansion coefficient of the sealing resin sheet after being cured.

[0072]

(Average Particle Diameter of Inorganic Filler)

Using a scanning electron microscope (SEM), a cross section of the sealing resin sheet was observed at 500 times, 10000 times, and 50000 times at an acceleration voltage of 5 kV. Using image software "Image J", a first average particle diameter targeting an inorganic filler of 0.1 μm or more in a visual field of 500 times, a second average particle diameter targeting an inorganic filler of 0.1 μm or more and less than 1 μm in a visual field of 10000 times, and a third average particle diameter targeting an inorganic filler of less than 0.01 μm in a visual field of 50000 times were calculated. The "average particle diameter" was calculated based on the first average particle diameter, the second average particle diameter, and the third average particle diameter. An area size was set

to the full field of view in the monitor.

[0073]

(Minimum Melt Viscosity)

Two circular shape sheets each having a diameter of 25 mm that were punched out from the sealing resin sheet were laminated to produce a cylindrical measurement sample having a diameter of 25 mm and a thickness of 1 mm. Regarding the minimum melt viscosity of the measurement sample, when a viscosity change was pursued with a viscoelasticity measuring apparatus "ARES" manufactured by Rheometric Scientific (measurement conditions: measuring temperature range of 50 to 150°C, temperature increase rate of 10°C/minute, frequency of 1 Hz, strain amount of 10%), the minimum value of the viscosity was measured.

[0074]

(Presence or Absence of Voids)

A cross section of a sealing resin sheet subjected to a heat treatment at 150°C for 1 hour was analyzed for presence or absence of voids at arbitrary five points of the sealing resin sheet. The case where a void was not present, or even if the void was present, the diameter of the void was 50 μm or less was evaluated as "O", and the case where the diameter of the void was more than 50 μm was evaluated as "X".

[0075]

(Smoothness of Inner Wall Surface of Via)

Using "LAVIA 1000W" manufactured by Sumitomo Heavy Industries, Ltd. (laser type: CO₂; transmitter output: 60 W; laser irradiation part output: 1.5 W; frequency: 500 Hz; and spot diameter: 0.1 mm), a sealing resin sheet subjected to a heat treatment at 150°C for 1 hour was irradiated with laser to form an opening (assuming a via) having a diameter of 50 μm. A cross section passing through the center of the via in plan view and along the height direction was observed with a microscope. The case where a height difference between the highest portion and the lowest portion of unevenness with respect to a reference line along the height direction was 5 μm or less was evaluated as "○". The case where the height difference was more than 5 μm and 10 μm or less was evaluated as "△". The case where the height difference was more than 10 μm was evaluated as "×".

[0076]

(Resin Press Deformability)

A sealing resin sheet cut into 10 cm × 10 cm was pressed with a flat plate press manufactured by Mikado Trading Co., Ltd. at a temperature of 90°C and a pressure of 350 kN for 1 minute. The case where the thickness after pressing was 150 μm or less was evaluated as "○", and the case where the thickness was more than 150 μm was evaluated as "×".

[0077]

(Warpage of Substrate)

A sealing resin sheet was molded by a flat plate press manufactured by Mikado Trading Co., Ltd. to be pasted (thickness after pasting: 100 μm) on a 10-cm square copper plate having a thickness of 30 μm , to produce a laminate of the copper plate and sealing resin sheet. The laminate was heated at 150°C for 1 hour in a heating oven, and the amount of warpage of the laminate was then measured. When the laminate was warped with the copper plate side facing inward, the laminate was placed on a flat plate with the copper plate side facing upward and the sealing resin sheet side facing downward. When the laminate was warped with the sealing resin sheet side facing inward, the laminate was placed on a flat plate with the copper plate side facing downward and the sealing resin sheet facing upward. The height from the surface of the parallel plate to the highest position was taken as an amount of warpage. The case where the amount of warpage was 5 mm or less was evaluated as "O". The case where the amount of warpage was more than 5 mm was evaluated as "X".

[0078]

[Table 1]

	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4
Forming method	Kneading	Kneading	Kneading	Kneading	Kneading	Kneading	Kneading	Kneading	Coating	Kneading	Kneading	Kneading
Epoxy resin 1	100	100	100	-	-	-	-	-	-	100	-	-
Epoxy resin 2	99	99	99	100	100	100	100	100	100	99	100	100
Epoxy resin 3	-	-	-	97	97	97	97	97	97	-	97	97
Phenol resin	89	89	89	90	90	90	90	90	90	89	90	90
Thermoplastic resin	-	-	-	-	-	-	127	-	-	-	-	127
Inorganic filler 1	685	755	882	-	-	-	-	-	-	653	-	-
Inorganic filler 2	-	-	-	680	1169	1967	2706	-	1169	-	512	3105
Inorganic filler 3	-	-	-	-	-	-	-	1169	-	-	-	-
Carbon	2	2	2	2	2	5	6	3	3	2	2	7
Curing accelerator	3	3	3	3	3	3	3	3	3	3	3	3
Silane coupling agent	2	2	3	1	1	2	9	1	1	2	1	12
Linear expansion coefficient [ppm/K]	24	18	12	28	13	10	11	11	12	29	33	7
Content of filler [wt%]	70	72	75	70	80	87	86	85	80	69	69	88
Average particle diameter of filler [μ m]	0.5	0.5	0.5	5	5	5	5	17	5	0.5	5	5
Minimum melt viscosity [Pa·s]	1	3	80	1	2	30	190	2	1	1	1	300
Presence or absence of voids	O	O	O	O	O	O	O	O	x	O	O	O
Smoothness of inner wall of via	O	O	O	O	O	O	O	Δ	O	O	O	O
Press deformability of resin	O	O	O	O	O	O	O	O	O	O	O	x
Warpage of substrate	O	O	O	O	O	O	O	O	O	x	x	x

[0079]

As can be seen from Table 1, the sealing resin sheets of Examples 1 to 7 could satisfactorily suppress both voids and warpage. On the other hand, Comparative Example 1 obtained by using a coating method caused voids, and Comparative Examples 2 to 4 had poor warpage evaluation results.

DESCRIPTION OF REFERENCE SIGNS

[0080]

1 Substrate

2 Electronic component

3 Sealing resin sheet

4 Via

10 Substrate having electronic component built therein

CLAIMS

1. A sealing resin sheet for a substrate having an electronic component built therein,
the sealing resin sheet having a single layer structure having a thickness of 150 μm or more and 1000 μm or less,
the sealing resin sheet having a linear expansion coefficient of 10 ppm/K or more and 28 ppm/K or less after a heat treatment at 150°C for 1 hour.
2. The sealing resin sheet for a substrate having an electronic component built therein according to claim 1, the sealing resin sheet comprises an inorganic filler having an average particle diameter of 0.5 μm to 5 μm , wherein a content of the inorganic filler is 70 to 87% by weight.
3. The sealing resin sheet for a substrate having an electronic component built therein according to claim 1 or 2, wherein the sealing resin sheet has a minimum melt viscosity of 1 Pa•s or more and 200 Pa•s or less in a temperature range of 50°C to 200°C.
4. The sealing resin sheet for a substrate having an electronic component built therein according to any one of claims 1 to 3, wherein the sealing resin sheet is formed by

kneading extrusion.

5. A method for manufacturing a substrate having an electronic component built therein, the method comprising the steps of:

disposing at least one electronic component in an opening portion formed in a substrate;

disposing the sealing resin sheet for a substrate having an electronic component built therein according to any one of claims 1 to 4 on a substrate so as to cover the opening portion;

heating and pressing the sealing resin sheet for a substrate having an electronic component built therein from an upper surface side of the sealing resin sheet, to fill the opening portion of the substrate with the sealing resin sheet; and

thermally curing the sealing resin sheet for a substrate having an electronic component built therein.