

SHEET FOR SEALING ELECTRONIC DEVICE AND METHOD FOR PRODUCING
ELECTRONIC DEVICE PACKAGE

BACKGROUND OF THE INVENTION

Field of the Invention

[0001]

The present invention relates to a sheet for sealing an electronic device, and a method for producing an electronic device package.

Description of the Related Art

[0002]

In order to produce an electronic device package, the following process is typically adopted: a process of using a sealing resin to seal one or more electronic devices fixed on, for example, a substrate through bumps or others to produce the package, which is a sealed body, and optionally dicing the sealed body so that the sealed body is made to be a package which is for an electronic device unit. As the sealing resin, a sealing resin in the form of a sheet may be used (see, for example, Patent Document 1 listed below).

Prior Art Document

Patent Document

[0003]

[0004]

The above-mentioned package producing method may be a method of laminating a sealing sheet onto one or more electronic devices arranged on an adherend to cover the electronic device(s), and subsequently curing the sealing sheet thermally. The thus produced package has a problem that at the time of the thermal curing, the package is warped by a difference in thermal expansion coefficient between the resin of the sealing sheet and the electronic device(s).

[0005]

It is conceivable that a method for restraining the package from being warped is, for example, a method of increasing the content by percentage of an inorganic filler in the sealing sheet. This method makes it possible to make the thermal expansion coefficient of the sealing sheet close to that of the electronic device(s).

[0006]

However, there remains the following problem: as the content by percentage of the inorganic filler in the sealing sheet is made larger, the viscosity of the sealing sheet becomes larger; thus, a predetermined proportion or more of the inorganic filler cannot be incorporated into the sheet.

SUMMARY OF THE INVENTION

[0007]

In light of the above-mentioned problem, the present invention has been made. An object thereof is to provide a sheet for sealing an electronic device that is low in viscosity and is a sheet into which an inorganic filler can be filled into a high level.

[0008]

The inventors have found out that constitutions or embodiments described below make it possible to solve the problem. Thus, the present invention has been achieved.

[0009]

Accordingly, the sheet for sealing an electronic device according to one of the constitutions of the invention includes:

a compound having one or more selected from the group consisting of a methacryloxy group and an acryloxy group as a silane coupling agent, and

an inorganic filler in a proportion of 69 to 86% by volume;
and

having a minimum viscosity ranging from 10 to 1000000 Pa·s.

[0010]

According to the constitution, the compound having a methacryloxy group or acryloxy group, which is unreactive with any thermosetting resin, is used as the silane coupling agent. Accordingly, the sheet can be restrained from being raised in viscosity by a reaction between the silane coupling agent and

any thermosetting resin. Moreover, the restraint of the viscosity rise, which is caused by the reaction between the agent and the thermosetting resin, makes it possible to increase the content by percentage of the inorganic filler.

Additionally, the inorganic filler is contained in a proportion ranging from 69 to 86% by volume; thus, the thermal expansion coefficient of the sheet can be made close to that of the electronic device. As a result, the resultant package can be restrained from being warped. Furthermore, the water absorption ratio of the sheet can be lowered since the inorganic filler is contained in a proportion ranging from 69 to 86% by volume. Moreover, the minimum viscosity ranges from 10 to 1000000 Pa·s; thus, the viscosity rise is restrained. As a result, any electronic device package that is produced using the present electronic device sealing sheet can have improved reliability.

[0011]

In the constitution, it is preferred that when the tensile storage modulus and the minimum viscosity of the sheet at 50°C are represented by X and Y, respectively, the ratio X/Y ranges from 15 to 100.

[0012]

On the basis of experimental results and others, the inventors have made eager investigations to find out that when the ratio X/Y is set to 15 or more, the sheet can attain a compatibility between handleability and

member-following-performance when a member with the sheet is shaped, so that such members can be shaped with a good yield. In the meantime, the inventors have found out that when the ratio X/Y is set to 100 or less, the sheet is not too hard so that the sheet can be prevented from being cracked or chipped at the time of the shaping.

[0013]

In the constitution, it is preferred that the inorganic filler is beforehand surface-treated with the silane coupling agent.

[0014]

When the surface of an inorganic filler is treated with a silane coupling agent, an outgas (for example, methane gas) is generated. Thus, at a stage before the present electronic device sealing sheet is produced, the inorganic filler is beforehand surface-treated with the silane coupling agent. This treatment makes it possible to exclude any outgas to some extent at this stage. As a result, when the electronic device sealing sheet is produced, the outgas volume confined inside the sheet can be controlled into a low level so that the generation of voids can be decreased.

[0015]

In the constitution, it is preferred that the inorganic filler is beforehand surface-treated with the silane coupling agent, the amount of which is from 0.5 to 2 parts by weight for

100 parts by weight of the inorganic filler.

[0016]

The surface-treatment of the inorganic filler with the silane coupling agent makes it possible to lower the viscosity of the electronic device sealing sheet. However, if the proportion of the silane coupling agent is large, the generated-outgas volume also increases. Consequently, even when the inorganic filler is beforehand surface-treated, the electronic device sealing sheet is lowered in performance by any outgas generated when the electronic device sealing sheet is produced. In the meantime, if the proportion of the silane coupling agent is small, the sheet cannot be appropriately decreased in viscosity. Thus, the inorganic filler is beforehand surface-treated with the silane coupling agent in an amount of 0.5 to 2 parts by weight for 100 parts by weight of the inorganic filler. This case makes it possible to decrease the viscosity appropriately and restrain the sheet from being lowered in performance by the outgas.

[0017]

The method according to the other constitution of the present invention for producing an electronic device package, including the steps of:

a preparing step of preparing the electronic device sealing sheet;

a laminating step of laminating the electronic device

sealing sheet over one or more electronic devices arranged over an adherend to cover the electronic device(s) with the sheet; and

a sealed body-forming step of curing the electronic device sealing sheet to form a sealed body.

[0018]

In this constitution, the above-mentioned electronic device sealing sheet is used, so that the electronic device package produced by the present electronic-device-package-producing method is restrained from being warped. As a result, the produced electronic device package can have improved reliability.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

Fig. 1 is a schematic view that schematically illustrates a sheet for sealing an electronic device according to an embodiment of the present invention;

Fig. 2A is a view that schematically illustrates a step of a method for producing a hollow package according to an embodiment of the present invention;

Fig. 2B is a view that schematically illustrates a step of the hollow package producing method according to the embodiment of the invention; and

Fig. 2C is a view that schematically illustrates a step

of the hollow package producing method according to the embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020]

Hereinafter, the present invention will be described in detail by way of embodiments thereof. However, the invention is not limited only to these embodiments.

[0021]

[Sheet for Sealing Electronic Device]

Fig. 1 is a sectional view that schematically illustrates a sheet 11 for sealing an electronic device (hereinafter referred to merely as the sealing sheet 11) according to an embodiment of the present invention. The sealing sheet 11 is supplied typically in the state of being laminated on a support 11a, such as a polyethylene terephthalate (PET) film. The support 11a may be subjected to releasing treatment for peeling the sealing sheet 11 easily.

[0023]

For the sealing sheet 11, a compound having a methacryloxy group or acryloxy group is used as a silane coupling agent. Since the compound having a methacryloxy group or acryloxy group, which is unreactive with any thermosetting resin, is used as the silane coupling agent, the sealing sheet 11 can be restrained from being raised in viscosity by a reaction between the sealing sheet and

the thermosetting resin.

[0024]

In the present specification, the wording "a compound having a methacryloxy group or acryloxy group is used as a silane coupling agent" includes, as the meaning thereof, the following cases:

(1) a case where the sealing sheet 11 contains an inorganic filler surface-treated beforehand with a compound having a methacryloxy group or acryloxy group as a silane coupling agent; and

(2) a case where the sealing sheet 11 contains a compound having a methacryloxy group or acryloxy group as a silane coupling agent.

[0025]

The silane coupling agent is not particularly limited as far as the agent is a compound which has a methacryloxy group or acryloxy group and which is a compound with which an inorganic filler can be surface-treated. Specific examples of the silane coupling agent include

3-methacryloxypropylmethyldimethoxysilane,

3-methacryloxypropyltrimethoxysilane,

3-methacryloxypropylmethyldiethoxysilane,

3-methacryloxypropyltriethoxysilane,

methacryloxyoctyltrimethoxysilane, and

methacryloxyoctyltriethoxysilane. Of these examples,

3-methacryloxypropyltrimethoxysilane is preferred from the viewpoint of reactivity and costs.

[0026]

The sealing sheet 11 contains an inorganic filler.

[0027]

The inorganic filler is not particularly limited, and may be an inorganic filler that may be of various types known in the prior art. Examples thereof include respective powders of quartz glass, talc, silica (such as fused silica or crystalline silica), alumina, aluminum nitride, silicon nitride, and boron nitride. These fillers may be used singly or in any combination of two or more thereof. Silica or alumina is preferred, and silica is more preferred since the filler can satisfactorily decrease the linear expansion coefficient of the sealing sheet 11.

[0028]

The species of silica is preferably silica powder, more preferably fused silica powder. Examples of the fused silica powder include spherical fused silica powder, and crushed fused silica powder. From the viewpoint of fluidity, spherical fused silica powder is preferred.

[0029]

The sealing sheet 11 contains the inorganic filler in a content by percentage which ranges from 69 to 86% by volume. The content by percentage is preferably 75% or more by volume,

more preferably 78% or more by volume. In order to incorporate the inorganic filler in the range of 69 to 86% by volume, the thermal expansion coefficient of the sheet can be made close to that of SAW chips 13. As a result, the resultant package can be restrained from being warped. Furthermore, in order to incorporate the inorganic filler in the range of 69 to 86% by volume, the water absorption ratio of the sheet can be made low.

[0030]

When the inorganic filler is silica, the content by percentage of the inorganic filler can also be described, using the unit of "% by weight". The silica content by percentage in the sealing sheet 11 is preferably from 80 to 92% by weight, more preferably from 85 to 92% by weight.

[0031]

The average particle diameter of the inorganic filler is preferably 20 μm or less, more preferably from 0.1 to 15 μm , in particular preferably from 0.5 to 10 μm .

The inorganic filler may be an inorganic filler composed of two or more inorganic filler species different from each other in average particle diameter. In the case of the two or more inorganic filler species different in average particle diameter, the wording "the average particle diameter of the inorganic filler is preferably 20 μm or less" means that the average particle diameter of the whole of the inorganic filler species is 20 μm or less.

[0032]

The form of the inorganic filler is not particularly limited, and may be any form such as a spherical (or elliptical), polyhedral, polygonal columnar, flat, or indeterminate form. The form is preferably a spherical form since the filler can attain a highly filled state in the vicinity of a hollow structure, and have an appropriate fluidity.

[0033]

It is preferable for the inorganic filler contained in the sealing sheet 11 to have two peaks in a particle size distribution thereof measured by a laser diffraction scattering method. This inorganic filler can be obtained, for example, by mixing two inorganic filler species different from each other in average particle diameter with each other.

The use of the inorganic filler, which has two peaks in the particle size distribution, makes it possible to fill the inorganic filler to have a high density. As a result, the content by percentage of the inorganic filler can be made larger.

The two peaks are not particularly limited. It is preferred that larger-particle-diameter one of the two peaks is present in a range in which the particle diameter is from 3 to 30 μm while the other, which is smaller in particle diameter, is present in a range in which that is from 0.1 to 1 μm . When the particle diameters of the peaks are in the respective numerical ranges, the content by percentage of the inorganic

filler can be made still larger.

Specifically, through the following process, the particle size distribution is obtained:

(a) The sealing sheet 11 is put into a crucible, and the crucible is intensely heated at 700°C in the air atmosphere for 2 hours to be incinerated.

(b) The resultant ash content is dispersed in pure water; the ash-dispersed water is subjected to ultrasonic treatment for 10 minutes; and then the (volume-reference) particle size distribution of the filler is obtained, using a laser diffraction scattering type particle size distribution measuring instrument ("LS 13 320" in a wet manner, manufactured by Beckman Coulter, Inc.).

In the composition of the sealing sheet 11, the compositions other than the inorganic filler are organic components, so that substantially the whole of the organic components is lost by the intensely heating treatment. Thus, the measurement is made under a condition that the resultant ash content is regarded as the inorganic filler. The calculation of the average particle diameter is also made simultaneously with the analysis of the particle size distribution.

[0034]

It is preferred in the sealing sheet 11 that the inorganic filler is beforehand surface-treated with the silane coupling agent. In short, the above-mentioned case (1) is preferred.

When the surface of the inorganic filler is treated with the silane coupling agent, an outgas (for example, methanol) is generated. Thus, at a stage before the sealing sheet 11 is produced, the inorganic filler is beforehand surface-treated with the silane coupling agent. This treatment makes it possible to exclude any outgas to some extent at this stage. As a result, when the sealing sheet 11 is produced, the outgas volume confined inside the sealing sheet can be controlled into a low level so that the generation of voids can be decreased.

[0035]

When the sealing sheet 11 contains the inorganic filler surface-treated beforehand with the compound having a methacryloxy group or acryloxy group as the silane coupling agent (the case (1)), it is preferred that the inorganic filler is beforehand surface-treated with the silane coupling agent in an amount of 0.5 to 2 parts by weight for 100 parts by weight of the inorganic filler.

When the inorganic filler is surface-treated with the silane coupling agent, the sealing sheet 11 can be lowered in viscosity; however, if the amount of the silane coupling agent is large, the generated outgas amount also increases. Accordingly, even when the inorganic filler is beforehand surface-treated, the sealing sheet 11 is lowered in performance by an outgas generated when the sealing sheet 11 is produced. In the meantime, if the amount of the silane coupling agent is

small, the sealing sheet cannot be appropriately lowered in viscosity. Thus, when the inorganic filler is beforehand surface-treated with the silane coupling agent in an amount of 0.5 to 2 parts by weight for 100 parts by weight of the inorganic filler, the sealing sheet can be appropriately lowered in viscosity and can be further restrained from being lowered in performance by the outgas.

[0036]

When the sealing sheet 11 contains the inorganic filler surface-treated beforehand with the compound having a methacryloxy group or acryloxy group as the silane coupling agent (the case (1)) and further the inorganic filler is an inorganic filler containing two inorganic filler species different from each other in average particle diameter, it is preferred that at least a species smaller in average particle diameter, out of the two filler species, is beforehand surface-treated with the silane coupling agent. Since the inorganic filler species smaller in average particle diameter is large in specific surface area, the rise in viscosity can be further restrained.

When the used inorganic filler is a mixture obtained by mixing two inorganic filler species different from each other in average particle diameter with each other, it is more preferred that both of a species smaller in average particle diameter out of the two species and the other, which is larger in average particle diameter, are beforehand surface-treated with the

silane coupling agent. In this case, the rise in the viscosity can be further restrained.

[0037]

When the sealing sheet 11 contains the compound having a methacryloxy group or acryloxy group as the silane coupling agent (the case (2)), the content by percentage of the silane coupling agent in the sealing sheet 11 is preferably from 0.4 to 1.8% by weight. When the content is 0.4% or more by weight, the sealing sheet can be appropriately lowered in viscosity. In the meantime, when the content is 1.8% or less by weight, the generation of an outgas can be restrained.

[0038]

About the sealing sheet 11, the minimum viscosity η ranges from 10 to 1000000 Pa·s, preferably from 5000 to 800000 Pa·s, more preferably from 10000 to 700000 Pa·s. The sealing sheet 11 has a minimum viscosity ranging from 10 to 1000000 Pa·s to be restrained from being raised in viscosity.

[0039]

About the sealing sheet 11, at the time of representing the tensile storage modulus and the minimum viscosity thereof at 50°C by X and Y, respectively, the ratio X/Y ranges preferably from 15 to 100 (1/s), more preferably from 20 to 80 (1/s), even more preferably from 30 to 60 (1/s). When the ratio X/Y is set to 15 or more, the sheet can attain a compatibility between handleability and member-following performance when a member

with the sheet is shaped. Thus, such members can be shaped with a good yield. In the meantime, when the ratio X/Y is set to 100 or less, the sheet is not too hard so that the sheet can be prevented from being cracked or chipped at the time of the shaping.

[0040]

The tensile storage modulus X of the sealing sheet 11 at 50°C ranges preferably from 200000 to 40000000 Pa, more preferably from 500000 to 13000000 Pa, even more preferably from 1000000 to 12000000 Pa. When the tensile storage modulus X is 200000 Pa or more, the sheet has a proper firmness and a good handleability. In the meantime, when the tensile storage modulus X is 40000000 Pa or less, the sealing sheet can be prevented from being cracked or chipped when handled.

[0041]

The sealing sheet 11 preferably contains an epoxy resin and a phenol resin. This case gives a good thermosetting performance to the sheet.

[0042]

The epoxy resin is not particularly limited. The resin may be an epoxy resin that may be of various types, examples thereof including triphenylmethane type epoxy resin, cresol novolak type epoxy resin, biphenyl type epoxy resin, modified bisphenol A type epoxy resin, bisphenol A type epoxy resin, bisphenol F type epoxy resin, modified bisphenol F type epoxy

resin, dicyclopentadiene type epoxy resin, phenol novolak type epoxy resin, and phenoxy resin. These epoxy resins may be singly or in any combination of two or more thereof.

[0043]

In order for the epoxy resin to ensure toughness after set, and ensure reactivity, the epoxy resin is preferably a resin having an epoxy equivalent of 150 to 250 and a softening point or melting point of 50 to 130°C to be in a solid form at any ordinary temperature. Of the above-mentioned examples, bisphenol F type epoxy resin, bisphenol A type epoxy resin, biphenyl type epoxy resin and others are more preferred from the viewpoint of shapability and reliability.

[0044]

The phenol resin is not particularly limited as far as the resin is a phenol resin which is combined with the epoxy resin to cause a setting reaction between the two resins. Examples thereof include phenol novolak resin, phenol aralkyl resin, biphenyl aralkyl resin, dicyclopentadiene type phenol resin, cresol novolak resin and resol resin. These phenol resins may be used singly or in any combination of two or more thereof.

[0045]

The phenol resin is preferably a resin having a hydroxyl equivalent of 70 to 250 and a softening point of 50 to 110°C from the viewpoint of reactivity with the epoxy resin. Of the above-mentioned examples, phenol novolak resin is preferred

since the resin is high in setting reactivity and is inexpensive. From the viewpoint of reliability, preferred is also a phenol resin low in hygroscopicity, such as phenol aralkyl resin or biphenyl aralkyl resin.

[0046]

About the blend ratio between the epoxy resin and the phenol resin, the phenol resin is blended with the epoxy resin to set the total amount of hydroxyl groups in the phenol resin into the range of 0.9 to 1.2 equivalents per equivalent of epoxy groups in the epoxy resin.

[0047]

The lower limit of the total content by percentage of the epoxy resin and the phenol resin in the sealing sheet 11 is preferably 5.0% by weight, more preferably 7.0% by weight. When the lower limit is 5.0% by weight, the sealing sheet can satisfactorily gain adhering strength to an electronic device, a substrate and others. In the meantime, the upper limit of the total content by percentage is preferably 25% by weight, more preferably 20% by weight. When the lower limit is 25% by weight, the sealing sheet can be decreased in hygroscopicity.

[0048]

The sealing sheet 11 preferably contains a thermoplastic resin. This case makes it possible to improve the sealing sheet in heat resistance, flexibility, and strength.

[0049]

Examples of the thermoplastic resin include natural rubber, butyl rubber, isoprene rubber, chloroprene rubber, ethylene/vinyl acetate copolymer, ethylene/acrylic acid copolymer, ethylene/acrylate copolymer, polybutadiene resin, polycarbonate resin, thermoplastic polyimide resin, polyamide resins such as 6-nylon and 6,6-nylon, phenoxy resin, acrylic resin, saturated polyester resins such as PET and PBT, polyamideimide resin, fluororesin, and styrene/isobutylene/styrene block copolymer. These thermoplastic resins may be used singly or in any combination of two or more thereof. Of these resins, acrylic resin is preferred since the resin causes the sealing sheet to gain flexibility easily, and is good in dispersibility in the epoxy resin.

[0050]

The acrylic resin is not particularly limited, and may be a polymer (acrylic copolymer) made from components including one or more acrylates or methacrylates (each) having a linear or branched alkyl group having 30 or less carbon atoms, particularly, 4 to 18 carbon atoms. Examples of the alkyl group include methyl, ethyl, propyl, isopropyl, n-butyl, t-butyl, isobutyl, amyl, isoamyl, hexyl, heptyl, cyclohexyl, 2-ethylhexyl, octyl, isooctyl, nonyl, isononyl, decyl, isodecyl, undecyl, lauryl, tridecyl, tetradecyl, stearyl, octadecyl, and dodecyl groups.

[0051]

The glass transition temperature (T_g) of the acrylic resin is preferably 50°C or lower, more preferably from -70 to 20°C, even more preferably from -50 to 0°C. By setting the glass transition temperature to 50°C or lower, the sheet can be caused to have flexibility.

[0052]

About the acrylic resin, the weight-average molecular weight is preferably 50000 or more, more preferably from 100000 to 2000000, even more preferably from 300000 to 1600000. When the weight-average molecular weight is 50000 or more, the sealing sheet 11 can be made higher in viscosity and flexibility. The weight-average molecular weight is a value obtained by making a measurement according to GPC (gel permeation chromatography) and making a calculation in terms of the molecular weight of polystyrene.

[0053]

One or more different monomers that are combined with the (meth)acrylate(s) to produce the polymer are not particularly limited. Examples thereof include carboxyl-group-containing monomers, such as acrylic acid, methacrylic acid, carboxyethyl acrylate, carboxypentyl acrylate, itaconic acid, maleic acid, fumaric acid, and crotonic acid; acid anhydride monomers, such as maleic anhydride, and itaconic anhydride; hydroxyl-group-containing monomers, such as 2-hydroxyethyl

(meth)acrylate, 2-hydroxypropyl (meth)acrylate, 4-hydroxybutyl (meth)acrylate, 6-hydroxyhexyl (meth)acrylate, 8-hydroxyoctyl (meth)acrylate, 10-hydroxydecyl (meth)acrylate, 12-hydroxylauryl (meth)acrylate, and (4-hydroxymethylcyclohexyl)-methyl acrylate; sulfonic-acid-group-containing monomers, such as styrenesulfonic acid, allylsulfonic acid, 2-(meth)acrylamide-2-methylpropanesulfonic acid, (meth)acrylamidepropanesulfonic acid, sulfopropyl (meth)acrylate, and (meth)acryloyloxynaphthalenesulfonic acid; and phosphate-group-containing monomers, such as 2-hydroxyethylacryloyl phosphate. It is particularly preferred that the different monomer(s) is/include at least one selected from carboxyl-group-containing monomers, glycidyl-group-containing (epoxy-group-containing) monomers, and hydroxyl-group-containing monomers since the different monomer(s) can react with the epoxy resin to heighten the sealing sheet 11 in viscosity.

[0054]

The content by percentage of the thermoplastic resin in the sealing sheet 11 is preferably 0.5% or more by weight, more preferably 1.0% or more by weight. When the content by percentage is 0.5% or more by weight, the sealing sheet can gain softness and flexibility. The content by percentage of the thermoplastic resin in the sealing sheet 11 is preferably 10% or less by weight,

more preferably 5% or less by weight. When the content by percentage is 10% or less by weight, the sealing sheet is good in adhesion or bondability to an electronic device or a substrate.

[0055]

The sealing sheet 11 preferably contains a curing promoter.

[0056]

The curing promoter is not particularly limited as far as the promoter causes the curing or setting of the epoxy resin and the phenol resin to advance. Examples thereof include organic phosphorus-containing compounds such as triphenylphosphine, and tetraphenylphosphonium tetraphenyl borate; and imidazole compounds such as 2-phenyl-4,5-dihydroxymethylimidazole, and 2-phenyl-4-methyl-5-hydroxymethylimidazole. Of these examples, imidazole compounds are preferred since the compounds are good in reactivity to heighten the Tg of the cured product easily.

[0057]

The content of the curing promoter is preferably from 0.1 to 5 parts by weight for 100 parts by weight of the total of the epoxy resin and the phenol resin.

[0058]

The sealing sheet 11 may contain a flame retardant, as required. This case makes it possible to decline burning expansion when the sheet catches fire by a short circuit or

heat-generation of the member concerned. Examples of the flame retardant include various metal hydroxides such as aluminum hydroxide, magnesium hydroxide, iron hydroxide, calcium hydroxide, tin hydroxide, and complex metal hydroxides; and phosphazene flame retardants.

[0059]

The sealing sheet 11 preferably contains a pigment. The pigment is not particularly limited, and may be, for example, carbon black.

[0060]

The content by percentage of the pigment in the sealing sheet 11 is preferably from 0.1 to 2% by weight. When the content by percentage is 0.1% or more by weight, the sheet gains a good marking performance. When the content by percentage is 2% or less by weight, the sealing sheet can ensure strength after cured.

[0061]

An additional additive other than the above-mentioned individual components may be appropriately blended into the resin composition, as required.

[0062]

[Method for Producing Sealing Sheet]

The sealing sheet 11 can be formed by dissolving or dispersing resins and others for forming the sealing sheet 11 into an appropriate solvent to prepare a varnish, painting this varnish into a predetermined thickness onto the support 11a to

form a paint film, and then drying the paint film under predetermined conditions. The method for the painting is not particularly limited, and may be, for example, roll painting, screen painting, or gravure painting. The drying conditions are, for example, as follows: the drying temperature is from 70 to 160°C; and the drying period is from 1 to 30 minutes. The sealing sheet 11 may be formed by painting the vanish onto a separator to form a paint film, and then drying the paint film under the above-mentioned drying conditions. Thereafter, the sealing sheet 11 together with the separator is bonded onto the support 11a. When the sealing sheet 11 contains, in particular, the above-mentioned thermoplastic resin (acrylic resin), epoxy resin and phenol resin, all of these components are dissolved into a solvent and then the resultant is painted and dried. Examples of the solvent include methyl ethyl ketone, ethyl acetate, and toluene.

[0063]

The thickness of the sealing sheet 11 is not particularly limited, and may be, for example, from 100 to 2000 μm . When the thickness is in this range, an electronic device can be satisfactorily sealed with the sheet.

[0064]

The sealing sheet 11 may have a mono-layered structure or a multi-layered structure in which two or more sealing sheets are laminated onto each other.

[0065]

[Method for Producing Hollow Package]

The following will describe a case where SAW chips are sealed with the sealing sheet 11 while hollows are created.

Figs. 2A to 2C are each a view that schematically illustrates a step of a method according to an embodiment of the present invention for producing a hollow package. The method for the sealing while the hollows are created is not particularly limited, and may be a sealing method known in the prior art. The method is, for example, a method of laminating (putting) the sealing sheet 11 in an uncured state onto an adherend, i.e., a substrate to cover electronic devices on the adherend while maintaining hollow structures on the adherend, and next curing the sealing sheet 11 to seal the electronic devices. The adherend is not particularly limited, and is, for example, a printed wiring substrate, a ceramic substrate, a silicon substrate, or a metallic substrate. In the present embodiment, SAW chips 13 mounted on a printed wiring substrate 12 are sealed with the sealing sheet 11 while hollows are created. In this way, a hollow package is produced. The SAW chips 13 are each a chip having a surface acoustic waver (SAW) filter.

[0066]

The hollow package producing method has an SAW-chip-mounted-substrate preparing step, a laminating step, a sealed-body-forming step, and a dicing step.

SAW-chip-mounted-substrate preparing step:

In the SAW-chip-mounted-substrate preparing step, the printed wiring substrate 12, on which the SAW chips 13 (SAW filters 13) are mounted, is prepared (see Fig. 2A). The SAW chips 13 can be formed by dicing a piezoelectric crystal on which predetermined comb-shaped electrodes are formed, in a known manner, to be made into individual pieces. In order to mount the SAW chips 13 onto the printed wiring substrate 12, a flip chip bonder, a die bonder or any other known machine is usable. The SAW chips 13 are electrically connected to the printed wiring substrate 12 through bump electrodes 13a such as bumps. Between each of the SAW chips 13, and the printed wiring substrate 12, a hollow region 14 is maintained not to hinder the transmission of surface acoustic waves in the front surface of the SAW filter. The distance between the SAW chip 13 and the printed wiring substrate 12 (the width of the hollow region) can be appropriately set, and is generally from about 10 to 100 μm .

[0067]

Laminating step:

In the laminating step, the sealing sheet 11 is laminated onto the printed wiring substrate 12 to cover the SAW chips 13, so that the SAW chips 13 are resin-sealed with the sealing sheet 11 (see Fig. 2B). The sealing sheet 11 functions as a sealing resin for protecting the SAW chips 13 and any element associated therewith from the external environment.

[0068]

The method for laminating the sealing sheet 11 onto the printed wiring substrate 12 is not particularly limited, and may be a known method, such as a method using a hot press or a laminator. Conditions for the hot press are, for example, as follows: the temperature is from 40 to 150°C, preferably from 50 to 120°C; the pressure is from 0.1 to 10 MPa, preferably from 0.5 to 8 MPa; and the period is from 0.3 to 10 minutes, preferably from 0.5 to 5 minutes. Considering an improvement in respective performances that the sealing sheet 11 adheres closely onto the SAW chips 13 and the printed wiring substrate 12, and that the sealing sheet 11 follows these members 13 and 12, it is preferred to attain the press under the condition of a reduced pressure (of, for example, 0.01 to 5 kPa).

[0069]

Sealed-body-forming step:

In the sealed-body-forming step, the sealing sheet 11 is thermally cured to form a sealed body 15 which is a package (see Fig. 2B). About a condition for the thermal curing, the heating temperature is preferably 100°C or higher, more preferably 120°C or higher. The upper limit of the heating temperature is preferably 200°C, more preferably 180°C. The heating period is preferably 10 minutes or longer, more preferably 30 minutes or longer. The upper limit of the heating period is preferably 180 minutes, more preferably 120 minutes. As required, the

workpiece may be pressurized. The pressure therefor is preferably 0.1 MPa or more, more preferably 0.5 MPa or more. The upper limit of the pressure is preferably 10 MPa, more preferably 5 MPa.

[0070]

Dicing step:

Subsequently, the sealed body 15 may be diced (see Fig. 2C). This step makes it possible to yield hollow packages 18 (electronic device packages) which are each for an SAW-chip-13-unit.

[0071]

Substrate mounting step:

As required, a substrate mounting step may be performed in which bumps are formed on any one or each of the hollow packages 18 and then the resultant is mounted onto a separate substrate (not illustrated). In order to mount the hollow package 18 onto the substrate, a flip chip bonder, a die bonder or any other known machine is usable.

[0072]

In the above-mentioned embodiment, the description has been made about a case where the electronic device sealing sheet 11 is a hollow-creating sealing sheet capable of sealing electronic devices while a hollow is caused to remain between each of the electronic devices and an adherend. However, the electronic device sealing sheet of the present invention is not

particularly limited. The sealing sheet may be, for example, a sheet with which an electronic device is sealed in such a form that no hollow region is caused to remain between an adherend and the electronic device.

[0073]

In the above-mentioned embodiment, the description has been made about a case where one or more electronic devices in the present invention are the SAW chips 13, which are each a semiconductor chip having a mobile section. However, the electronic device(s) in the invention is/are not limited to this example. The electronic device(s) may (each) be a semiconductor chip having, as a mobile section thereof, a micro electro mechanical system (MEMS), such as a pressure sensor or a vibration sensor. The electronic device(s) may (each) be a semiconductor chip having no mobile section, or a capacitor, a resistor or some other.

Examples

[0074]

Hereinafter, preferred working examples of the present invention will be demonstrated in detail. However, materials, blend amounts and others that are described in the examples do not limit the scope of this invention as far as the claims do not include a restricted recitation thereabout.

[0075]

Components used in the examples are described as follows:

Epoxy resin: a product, YSLV-80 XY (bisphenol F type epoxy resin), manufactured by Nippon Steel Chemical Co., Ltd.; epoxy equivalent: 200 g/eq., and softening point: 80°C;

Phenol resin: a product, LVR 8210 DL (novolak type phenol resin), manufactured by Gunee Chemical Industry Co., Ltd.; hydroxyl equivalent: 104 g/eq., and softening point: 60°C;

Thermoplastic resin: a product, HME-2006 M (carboxyl-group-containing acrylate copolymer), manufactured by Negami Chemical Industrial Co., Ltd.; weight-average molecular weight: about 600000, and glass transition temperature (T_g): -35°C;

Inorganic filler A: a filler obtained by surface-treating a product, FB-5SDC (average particle diameter: 5 μm), manufactured by Denki Kagaku Kogyo K.K. with 3-methacryloxypropyltrimethoxysilane (product name: KBM-503, manufactured by Shin-Etsu Chemical Co., Ltd.), the amount of the silane coupling agent being 1 part by weight for 100 parts by weight of the inorganic filler A;

Inorganic filler B: a filler obtained by surface-treating a product, SO-25R (average particle diameter: 0.5 μm), manufactured by Admatechs Co., Ltd. with 3-methacryloxypropyltrimethoxysilane (product name: KBM-503, manufactured by Shin-Etsu Chemical Co., Ltd.), the amount of the silane coupling agent being 1 part by weight for 100 parts

by weight of the inorganic filler B;

Inorganic filler C: the product FB-5SDC (surface-treated with no agent; average particle diameter: 5 μm), manufactured by Denki Kagaku Kogyo K.K.;

Inorganic filler D: the product SO-25R (surface-treated with no agent; average particle diameter: 0.5 μm), manufactured by Admatechs Co., Ltd.;

Silane coupling agent:

3-methacryloxypropyltrimethoxysilane (product name: KBM-503, manufactured by Shin-Etsu Chemical Co., Ltd.);

Carbon black: #20, manufactured by Mitsubishi Chemical Corp.; and

Curing promoter: a product, 2PHZ-PW (2-phenyl-4,5-dihydroxymethylimidazole), manufactured by Shikoku Chemicals Corp.

[0076]

[Examples and Comparative Example]

In each of the examples, in accordance with a blend ratio based on respective amounts of individual components that are described in Table 1, the components were dissolved or dispersed in methyl ethyl ketone as a solvent to yield a varnish having a concentration of 90% by weight. This varnish was painted onto a releasing-treated film that was a 38- μm -thickness polyethylene terephthalate film subjected to releasing treatment with silicone, and then dried at 110°C for 5 minutes. In this way,

a 65- μm -thickness sheet was yielded. This sheet and the same sheets, the total number of which was four, were laminated onto each other to produce each hollow-creating sealing sheet of thickness of 260 μm .

[0077]

[Table 1]

		Example 1	Example 2	Example 3	Example 4	Comparative Example 1
Blend amount (part(s) by weight)	Epoxy resin	10.0	6.3	4.8	6.3	6.3
	Phenol resin	5.5	3.5	2.6	3.5	3.5
	Thermoplastic resin	2.8	1.8	1.3	1.9	1.8
	Inorganic filler A (surface-treated; average particle diameter: 5 μm)	-	-	63.7	-	-
	Inorganic filler B (surface-treated; average particle diameter: 0.5 μm)	24.3	26.4	27.3	-	-
	Inorganic filler C (not surface-treated; average particle diameter: 5 μm)	56.7	61.6	-	61.0	61.6
	Inorganic filler D (not surface-treated; average particle diameter: 0.5 μm)	-	-	-	26.0	26.4
	Silane coupling agent	-	-	-	0.90	-
	Carbon black	0.57	0.30	0.24	0.30	0.30
	Curing promoter	0.13	0.10	0.06	0.10	0.10
Total amount (parts by weight)		100	100	100	100	100
Sheet thickness (μm)		200	200	200	200	200
Content (% by volume) in inorganic filler in sheet		70	80	85	79	80
Content (% by weight) in inorganic filler in sheet		81	88	91	87	88

[0078]

Tensile Storage Modulus of Sealing Sheet At 50°C:

A viscoelasticity measuring instrument (model: RSA-II, manufactured by Rheumatic Scientific, Inc.) was used to measure the tensile storage modulus X of one of the sealing sheets produced in each of the working examples and the comparative example. Specifically, one of the produced sealing sheets was cut to prepare a sample having a size of 30 mm length and 5 mm width. The measuring sample was set to a tool for film-tension-measurement, and then the tensile storage modulus thereof was measured in the range of temperatures of -20 to 100°C under conditions that the frequency was 1 Hz, the strain was 0.1%, and the temperature-raising rate was 10°C/min. The results are shown in Table 2.

[0079]

Measurement of Minimum Viscosity of Sealing Sheet:

A rheometer (MARS III, manufactured by Haake Technik GmbH) was used to measure the minimum viscosity of one of the sealing sheets produced in each of the working examples and the comparative example by a parallel plate method. Specifically, the viscosity of the sheet was measured in the range of 50 to 130°C under conditions that the gap was 1 mm, the parallel plate diameter was 8 mm, the rotation number was 5 s⁻¹, the strain was 0.05%, and the temperature-raising rate was 10°C/min. The minimum value of the viscosity values obtained at this time was

defined as the minimum viscosity. The results are shown in Table 2.

The ratio X/Y in each of the examples is also in Table 2.

[0080]

Evaluation of Flexibility and Tackiness of Sealing Sheet:

Two plates each having a diameter of 25 mm were set to a viscoelasticity measuring instrument (RSA-3, manufactured by a company, TA Instruments). One of the sealing sheets of each of the working examples and the comparative example was fixed onto lower one of the two plates through a double-sided tape. Thereafter, the upper plate (probe) was lowered in the atmosphere of 25°C temperature to push the upper plate onto the sealing sheet with a load of 100 g. Thereafter, by raising the upper plate, a measurement was made about the load necessary for peeling the upper plate off from the sealing sheet. When the load was 5 g or more, the sealing sheet was determined to be good (circular mark), or when the load was less than 5 g, the sealing sheet was determined to be bad (cross mark). The results are shown in Table 2.

[0081]

Evaluation of Warp Quantity of Sealing Sheet After Sheet-Curing:

About the warp quantity of one of the sealing sheets of each of the working examples and the comparative example after the sheet was cured, a measurement was made as follows:

The sealing sheet, the size of which was set to a size of 100 mm x 100 mm and a thickness of 0.2 mm, was compressed onto an alumina substrate having the same size and thickness at 100°C under a pressure of 0.5 kgf/cm² for 30 seconds. Thereafter, an oven was used to cure the sealing sheet at 150°C for 1 hour, and then the present test specimen was naturally cooled to room temperature. At this time, the maximum warp quantity was measured with a vernier micrometer. Specifically, the sealing sheet was put onto a flat stand to face the sealing sheet upward. The distance between a portion of the sheet that was farthest from the front surface of the stand, and the front surface was measured as the thickness of the sealing sheet. Next, from the resultant measurement thickness, the thickness (0.5 mm) of the alumina substrate and that (0.2 mm) of the sealing sheet were subtracted. The resultant value was defined as the warp quantity of the sealing sheet. When the warp quantity was less than 2 mm, the sealing sheet was determined to be good (circular mark), or when the warp quantity was 2 mm or more, the sealing sheet was determined to be bad (cross mark). The results are shown in Table 2.

[0082]

Evaluation of Resin Invasion of Sealing Sheet into Package Hollow Region:

SAW chips each having formed aluminum comb-shaped electrodes and having a specification described below were

mounted onto a ceramic substrate under bonding conditions described below to produce each SAW-chip-mounted substrate. The width of a gap between each of the SAW chips and the ceramic substrate was 15 μm .

[0083]

<SAW chips>

Chip size: 1.2-mm square (thickness: 150 μm)

Bump material: Au (height: 15 μm)

The number of the bumps: 6

The number of the chips: 100 (10 x 10)

[0084]

<Bonding machine/conditions>

Machine: a machine manufactured by Panasonic Corp.

Bonding conditions: a temperature of 200°C, a force of 3 N, a period of 1 sec and an ultrasonic power of 2 W

[0085]

One of the sealing sheets of each of the examples was bonded onto one of the resultant SAW-chip-mounted substrates by vacuum press under heating and pressurizing conditions described below.

[0086]

<Sheet-bonding conditions>

Temperature: 60°C

Applied pressure: 4 MPa

Vacuum degree: 1.6 kPa

Press period: 1 minute

[0087]

The machine for the press was released to the atmospheric pressure, and then the sealing sheet was thermally set in a hot-wind drier at 150°C for 1 hour to yield a sealed body. The resultant sealed body was cleaved at the interface between the substrate and the sealing resin thereof. A microscope (trade name: "DIGITAL MICROSCOPE"), manufactured by Keyence Corp. was used (magnifying power of 200) to measure the invasion quantity of the resin into the hollow region between any one of the SAW chips and the ceramic substrate. At this time, the measurement was made about the maximum arrival distance of the resin invaded the hollow region from an end of the SAW chip. This distance was defined as the resin invasion quantity. If no invasion was caused and the hollow region spread outside the SAW chip, the resin invasion quantity was represented by a numerical value with a minus sign. When the resin invasion quantity was from -50 to 50 μm , the sealing sheet was determined to be good (circular mark), or when the resin invasion quantity was less than -50 μm or more than 50 μm , the sealing sheet was determined to be bad (cross mark). The results are shown in Table 2.

[0088]

[Table 2]

		Example 1	Example 2	Example 3	Example 4	Comparative Example 1
Modulus X (Pa) at 50°C		275,000	12,200,000	40,000,000	11,000,000	15,000,000
Minimum viscosity Y (Pa·s)		12,300	300,000	700,000	400,000	1,100,000
Ratio X/Y (1/s)		22.4	40.7	57.1	27.5	13.6
Flexibility and tackiness		○	○	○	○	×
Warp quantity after sheet-curing	mm	1.7	0.9	0.8	0.9	1.3
	Determination	○	○	○	○	○
Invasion of resin into hollow region	Gap width (μm)	15	15	15	15	15
	Invasion quantity (μm)	30	15	10	17	-150
	Determination	○	○	○	○	×

What is claimed is:

1. A sheet for sealing an electronic device,

comprising:

a compound having one or more selected from the group consisting of a methacryloxy group and an acryloxy group as a silane coupling agent, and

an inorganic filler in a proportion of 69 to 86% by volume;

and

having a minimum viscosity ranging from 10 to 1000000 Pa.s.

2. The electronic device sealing sheet according to claim

1,

about which when the tensile storage modulus and the minimum viscosity of the sealing sheet at 50°C are represented by X and Y, respectively, the ratio X/Y ranges from 15 to 100.

3. The electronic device sealing sheet according to claim

1 or 2, wherein the inorganic filler is beforehand surface-treated with the silane coupling agent.

4. The electronic device sealing sheet according to claim

3, wherein the inorganic filler is beforehand surface-treated with the silane coupling agent, the amount of the agent being from 0.5 to 2 parts by weight for 100 parts by weight of the inorganic filler.

5. A method for producing an electronic device package, comprising:

a preparing step of preparing the electronic device sealing sheet recited in any one of claims 1 to 4;

a laminating step of laminating the electronic device sealing sheet over one or more electronic devices arranged over an adherend to cover the electronic device(s) with the sealing sheet; and

a sealed body-forming step of curing the electronic device sealing sheet to form a sealed body.