

DESCRIPTION

TITLE OF THE INVENTION: HOLLOW SEALING RESIN SHEET AND
PRODUCTION METHOD FOR HOLLOW PACKAGE

TECHNICAL FIELD

[0001]

The present invention relates to a hollow sealing resin sheet and a production method for a hollow package.

BACKGROUND ART

[0002]

In order to produce electronic device packages, the following process is typically adopted: a process of sealing with a sealing resin one or more electronic devices fixed to a substrate to interpose bumps or the like therebetween, and optionally dicing the sealed body into the packages, which are each an electronic device unit. As such a sealing resin, a sheet-form sealing resin may be used.

[0003]

In recent years, the development of not only semiconductor packages but also micro electro mechanical systems called MEMS has been advanced, examples of the MEMS including SAW (surface acoustic wave) filters, CMOS (complementary metal oxide semiconductor) sensors, and acceleration sensors. Packages in which these electronic

devices are sealed up generally have hollow structures for ensuring the transmission of surface acoustic waves, the maintenance of an optical system, and the mobility of a movable member of an electronic device, respectively. The hollow structures are each provided as a gap between a substrate and an element in many cases. In order to ensure the operation reliability of the movable member or the connection reliability of the element when the member or element is sealed up, it is necessary to attain the sealing while the hollow structure is maintained. For example, Patent Document 1 describes a technique of using a gelatinous curable resin sheet to subject a functional element to hollow molding.

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0004]

Patent Document 1: JP-A-2006-19714

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0005]

In light of a situation that as bumps for giving the above-mentioned hollow structure are smaller in size, costs become higher, and a request that the hollow structure should be enlarged to make the movable member into a complicated or

composite form, it is expected to take measures of increasing the bumps in diameter hereafter to enlarge the gap. According to the technique described in Patent Document 1, when a hollow structure between an element and a substrate is a gap having a width up to several tens of micrometers, an electronic device can be sealed up while the structure keeps a desired hollow structure. However, in the case of attempting such sealing while the hollow structure keeps a gap having a width of about 100 μm , the resin flows into the hollow structure, or other inconveniences are caused to make it difficult to attain the sealing. Thus, the production yield of packages may be lowered.

[0006]

An object of the present invention is to provide a hollow sealing resin sheet which makes it possible to produce a hollow package with a high yield even when a gap in its hollow structure has a width of about 100 μm ; and a production method for a hollow package.

MEANS FOR SOLVING THE PROBLEMS

[0007]

The inventors have made eager investigations to find out that the above-mentioned problems can be solved by adopting a structure described below, and then have achieved the present invention.

[0008]

Accordingly, the hollow sealing resin sheet of the present invention contains an inorganic filler in a content of 70 to 90% by volume both inclusive, wherein:

in the particle diameter distribution of the inorganic filler that is measured by a laser diffraction scattering method, at least one frequency distribution peak is present in the particle diameter range of 1 to 10 μm both inclusive, and further at least one frequency distribution peak is present in the particle diameter range of more than 10 μm and not more than 100 μm ; and

the inorganic filler has a BET specific surface area of 2 to 5 m^2/g both inclusive.

[0009]

The hollow sealing resin sheet contains the inorganic filler, which has the predetermined particle diameter distribution and the BET specific surface area, in the high content; thus, while the inorganic filler is restrained from aggregating, a flow-regulating effect (dilatancy-like effect) is given to the resin in the vicinity of a hollow structure. Thus, the entry of the resin into the hollow structure can be efficiently prevented. As a result, even when the width of a gap thereof is about 100 μm , a hollow package can be produced with a high yield while the hollow structure is maintained. Respective methods for measuring the content, the particle diameter distribution, and the BET specific surface area of the

inorganic filler are according to the description of EXAMPLES.

[0010]

The hollow sealing resin sheet preferably has a dynamic viscosity of 5000 to 30000 Pa·s both inclusive at 80°C before cured. This manner makes it possible to make the following compatible with each other more satisfactorily: sure retention of the hollow structure; and the property of the sheet that follows irregularities in portions (the substrate surface or the chips) other than the hollow structure. A method for measuring the dynamic viscosity is according to the description of EXAMPLES.

[0011]

In the hollow sealing resin sheet, the inorganic filler is preferably silica particles, alumina particles, or a mixture of these particles. This manner makes it possible to lower the linear expansion coefficient of the sheet after the sheet is cured to yield a highly reliable package.

[0012]

In the hollow sealing resin sheet, the inorganic filler is preferably spherical. This manner makes it possible to blend the inorganic filler in a higher content to make the inorganic filler into a highly filled state, and exhibit the resin flow regulating effect more efficiently.

[0013]

The present invention also includes a production method

for a hollow package, including:

a laminating step of laminating the hollow sealing resin sheet over one or more electronic devices arranged on an adherend to cover the electronic devices while a hollow region is maintained between the adherend and the electronic devices; and

a sealed body forming step of curing the hollow sealing resin sheet to form a sealed body.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig. 1 is a sectional view that schematically illustrates a resin sheet according to one embodiment of the present invention.

Fig. 2A is a drawing that schematically illustrates a step of a hollow package production method according to one embodiment of the invention.

Fig. 2B is a drawing that schematically illustrates a step of the hollow package production method according to the embodiment of the invention.

Fig. 2C is a drawing that schematically illustrates a step of the hollow package production method according to the embodiment of the invention.

Fig. 3 is a frequency distribution curve obtained by measuring particle diameter distribution of an inorganic filler

in a hollow sealing resin sheet of Example 3 of the present invention.

MODE FOR CARRYING OUT THE INVENTION

[0015]

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

[0016]

<<First Embodiment>>

[Hollow sealing resin sheet]

[0017]

Fig. 1 is a sectional view that schematically illustrates a hollow sealing resin sheet (hereinafter also simply referred to as a "resin sheet") 11 according to one embodiment of the present invention. The resin sheet 11 is typically supplied 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 in order to cause the resin sheet 11 to be easily peeled therefrom.

[0018]

The resin sheet 11 preferably contains an epoxy resin and a phenol resin. In this way, the resin sheet can gain good thermal curability.

[0019]

The epoxy resin is not particularly limited. Various kinds of epoxy resins can be used such as, for example, a triphenylmethane-type epoxy resin, a cresol novolac-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, dicyclopentadiene-type epoxy resin, a phenol novolac-type epoxy resin and a phenoxy resin. These epoxy resins may be used alone or in combination of two or more thereof.

[0020]

An epoxy resin which has an epoxy equivalent of 150 to 250 and a softening point or melting point of 50 to 130°C and is solid at ordinary temperature is preferred from the viewpoint of securing toughness after curing of the epoxy resin and reactivity of the epoxy resin, and particularly a triphenylmethane-type epoxy resin, a cresol novolac-type epoxy resin and a biphenyl-type epoxy resin are further preferred from the viewpoint of reliability.

[0021]

The phenol resin is not particularly limited as long as it causes a curing reaction with the epoxy resin. For example, a phenol novolac resin, a phenol aralkyl resin, a biphenyl aralkyl resin, a dicyclopentadiene-type phenol resin, a cresol novolac resin, a resol resin and the like are used. These phenol resins may be used alone or in combination of two or more thereof.

[0022]

As the phenol resin, a phenol resin having a hydroxyl equivalent of 70 to 250 and a softening point of 50 to 110°C is preferably used from the viewpoint of reactivity with the epoxy resin, and particularly a phenol novolac resin can be suitably used because of its high curing reactivity. A phenol resin having low hygroscopicity, such as a phenol aralkyl resin and a biphenyl aralkyl resin, can also be suitably used from the viewpoint of reliability.

[0023]

The epoxy resin and the phenol resin are blended in such a ratio that the total amount of hydroxyl groups in the phenol resin is preferably 0.7 to 1.5 equivalents, more preferably 0.9 to 1.2 equivalents, based on 1 equivalent of epoxy groups in the epoxy resin from the viewpoint of curing reactivity.

[0024]

The lower limit of the total content of the epoxy resin and the phenol resin in the resin sheet 11 is preferably 2.0% by weight or more, more preferably 3.0% by weight or more. When the lower limit is 2.0% by weight or more, the resin sheet can gain good adhering strength onto an electronic device, a substrate and others. In contrast, the upper limit of the total content is preferably 20% by weight or less, more preferably 10% by weight or less. When the upper limit is 20% by weight or less, the resin sheet can be decreased in hygroscopicity.

[0025]

The resin sheet 11 preferably contains a thermoplastic resin. This manner makes it possible to improve the resultant hollow sealing resin sheet in heat resistance, plasticity and strength.

[0026]

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, polyamide-imide resin, fluororesin, and styrene-isobutylene-styrene block copolymer. These thermoplastic resins are usable singly or in any combination of two or more thereof. Of these resins, styrene-isobutylene-styrene block copolymer is preferred from the viewpoint of a low stress property and low water absorption of the resin sheet.

[0027]

The content of the thermoplastic resin in the resin sheet 11 is preferably 1.0% by weight or more, more preferably 1.5% by weight or more. When the content is 1.0% by weight or more, flexibility and plasticity can be favorably given to the resin

sheet. The content of the thermoplastic resin in the resin sheet 11 is preferably 3.5% by weight or less, more preferably 3.0% by weight or less. When the content is 3.5% by weight or less, the resin sheet can have good adhesion to an electronic device or a substrate.

[0028]

The resin sheet 11 contains an inorganic filler in a content of 70 to 90% by volume both inclusive. The lower limit of the content is preferably 74% by volume or more, more preferably 78% by volume or more. The upper limit of the content is preferably 85% by volume or less, more preferably 83% by volume or less. When the content of the inorganic filler is set within the above-mentioned range, dilatancy-like effect is favorably given to the resin in the vicinity of the hollow structure so that the hollow structure can be maintained. Additionally, after cured, the resin sheet is lowered in linear expansion coefficient so that the package can be prevented from being warped. Thus, the hollow package with high reliability can be obtained. If the content of the inorganic filler is less than the lower limit, the dilatancy-like effect may not be sufficiently obtained, or the package may be warped. If the content is more than the upper limit, the resin sheet may be lowered in fluidity and flexibility to be lowered in adhesion to a substrate or a chip. When the inorganic filler is made of a mixture of plural particle species, the content of the

mixture satisfies the above-mentioned range.

[0029]

The content of the inorganic filler can also be described using "% by weight" as the unit thereof. The content of silica, which is a typical example of the inorganic filler, will be described using "% by weight" as the unit.

Silica usually has a specific gravity of 2.2 g/cm^3 . Thus, a preferred range of the content (% by weight) of silica is as follows: the content of silica in the resin sheet 11 is preferably 81% by weight or more, more preferably 84% by weight or more; and the content of silica in the resin sheet 11 is preferably 94% by weight or less, more preferably 91% by weight or less.

[0030]

Alumina usually has a specific gravity of 3.9 g/cm^3 . Thus, a preferred range of the content (% by weight) of alumina is as follows: the content of alumina in the resin sheet 11 is preferably 88% by weight or more, more preferably 90% by weight or more; and the content of alumina in the resin sheet 11 is preferably 97% by weight or less, more preferably 95% by weight or less.

[0031]

About the resin sheet 11, in the particle diameter distribution of the inorganic filler that is measured by a laser diffraction scattering method, at least one frequency

distribution peak is present in the particle diameter range of 1 to 10 μm both inclusive, and further at least one frequency distribution peak is present in the particle diameter range more than 10 μm and not more than 100 μm . In each of these particle diameter ranges, it is sufficient for at least one frequency distribution peak to be independently present. Two or more peaks may be present. However, from the viewpoint of making the composition simple, it is sufficient for the frequency distribution peak(s) present in each of the particle diameter ranges to be one in number. When the particle diameter distribution of the inorganic filler, which is according to a laser diffraction scattering method, has the above-mentioned specified relationship, the inorganic filler in the vicinity of the hollow structure gains a highly filled state. In this way, a dilatancy-like effect is given to the resin. Thus, at the time of the sealing, the entry of the resin into the hollow structure can be favorably restrained. When the inorganic filler is a mixture of plural particle species, the particle diameter distribution of the mixture satisfies the above-mentioned relationship.

[0032]

The BET specific surface area of the inorganic filler is not particularly limited as far as the surface area ranges from 2 to 5 m^2/g both inclusive. The lower limit thereof is preferably 2.0 m^2/g or more, more preferably 2.5 m^2/g or more.

The upper limit of the BET specific surface area is preferably $5.0 \text{ m}^2/\text{g}$ or less, more preferably $4.5 \text{ m}^2/\text{g}$ or less. By setting the BET specific surface area of the inorganic filler within the above-mentioned range, the inorganic filler can attain a highly filled state while restrained from aggregating, and further the dilatancy-like effect can be more efficiently given to the resin. If the BET specific surface area of the inorganic filler is less than the lower limit, the particles coarsen so that interaction between the particles becomes small. Thus, the dilatancy-like effect may not be sufficiently gained. If the BET specific surface area is more than the upper limit, the particles aggregate strongly so that the irregularity-following property of the resin sheet may be deteriorated.

[0033]

The shape of the inorganic filler is not particularly limited, and may be any shape such as a spherical shape (the shape may be an elliptic shape), a polyhedral shape, a polygonal columnar shape, or an indeterminate shape. The spherical shape is preferred from the viewpoint that the resin attains a highly filled state in the vicinity of the hollow structure, and gains appropriate fluidity.

[0034]

The inorganic filler is not particularly limited, various kinds of previously known fillers can be used, and examples

thereof include powders of quartz glass, talc, silica (fused silica, crystalline silica, etc.), alumina, aluminum nitride, silicon nitride and boron nitride. They may be used alone or in combination of two or more thereof. Of these examples, silica and alumina are preferred and silica is more preferred since the fillers make it possible to decrease the linear expansion coefficient satisfactorily.

[0035]

As the species of silica, silica powder is preferred, and fused silica powder is more preferred. Examples of fused silica powder include spherical fused silica powder and crushed fused silica powder. Spherical fused silica powder is preferred from the viewpoint of the fluidity thereof.

[0036]

The average particle diameter of the inorganic filler is preferably 50 μm or less, and ranges more preferably 0.1 to 30 μm , in particular preferably 0.5 to 20 μm . The average particle diameter can be derived as D_{50} according to procedures of a particle diameter distribution measurement in the Examples.

[0037]

The resin sheet 11 preferably contains a curing accelerator.

[0038]

The curing accelerator is not particularly limited as far as it is a substance for advancing the curing of the epoxy resin

and the phenol resin. Examples thereof 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. Of these examples, 2-phenyl-4,5-dihydroxymethylimidazole is preferred since the curing reaction is not abruptly advanced by a rise in the temperature when raw materials for the resin sheet are kneaded, so that the resin sheet 11 can be satisfactorily produced.

[0039]

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

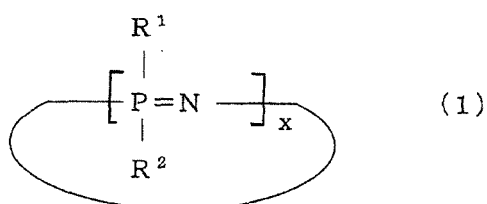
[0040]

The resin sheet 11 preferably contains a flame retardant component. This manner makes it possible to decrease expansion of burning when a product including the resin sheet ignites by effect of a short circuit of its component, heat generated therefrom, or some other. As the flame retardant component, various kinds of metal hydroxides such as, for example, aluminum hydroxide, magnesium hydroxide, iron hydroxide, calcium hydroxide, tin hydroxide and conjugated metal hydroxides, and phosphazene-based flame retardants can be used. Of these examples, phosphazene-based flame retardants are preferred

since the resin sheet containing the flame retardant is excellent in flame retardancy, flexibility before curing and strength after cured. A compound represented by the following formula (1) or (2) is preferred.

[0041]

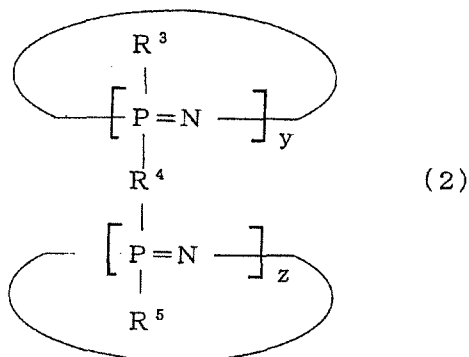
[Formula 1]



(wherein, R^1 and R^2 are the same or different, and are each a monovalent organic group having a group selected from the group consisting of an alkoxy group, a phenoxy group, an amino group, a hydroxyl group, an allyl group and these groups. x is an integer of 3 to 25.)

[0042]

[Formula 2]



(wherein, R^3 and R^5 are the same or different, and are each a monovalent organic group having at least one group selected from

the group consisting of an alkoxy group, a phenoxy group, an amino group, a hydroxyl group, an allyl group and these groups. R^4 is a divalent organic group having a functional group selected from the group consisting of an alkoxy group, a phenoxy group, an amino group, a hydroxyl group and an allyl group. y is an integer of 3 to 25. z is an integer of 3 to 25.)

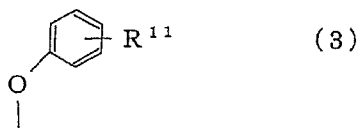
[0043]

Examples of the alkoxy group for R^1 and R^2 include methoxy, ethoxy, n-propoxy, isopropoxy, n-butoxy, and t-butoxy groups. Particularly preferred are alkoxy groups each having 4 to 10 carbon atoms.

[0044]

The phenoxy group for R^1 and R^2 is, for example, a group represented by the following formula (3):

[Formula 3]



wherein R^{11} represents hydrogen or a hydroxyl, alkyl, alkoxy or glycidyl group, or a monovalent organic group having at least one group selected from the group consisting of these groups.

[0045]

Examples of the alkyl group for R^{11} include methyl, ethyl, n-propyl, isopropyl, n-butyl, iso-butyl, sec-butyl, tert-butyl, pentyl, hexyl, heptyl, 2-ethylhexyl, octyl, nonyl,

decyl, undecyl, dodecyl, tridecyl, tetradecyl, pentadecyl, and octadecyl groups. Examples of the alkoxy group for R^{11} are the same groups as described as the alkoxy group for R^1 and R^2 .

[0046]

R^1 and R^2 are each preferably a phenoxy group, more preferably the group represented by the formula (3) since this case results in giving, to the resin sheet, good flame retardancy and good strength after the resin sheet is cured.

[0047]

The symbol x represents an integer of 3 to 25, and is preferably 3 to 10, more preferably 3 to 4 since this case results in giving, to the resin sheet, good flame retardancy and good strength after the resin sheet is cured.

[0048]

In the formula (2), examples of the alkoxy group for R^3 and R^5 include methoxy, ethoxy, n-propoxy, isopropoxy, n-butoxy, and t-butoxy groups. Particularly preferred are alkoxy groups each having 4 to 10 carbon atoms.

[0049]

The phenoxy group for R^3 and R^5 is, for example, the group represented by the formula (3).

[0050]

About each of R^3 and R^5 , the monovalent organic group having at least one group selected from the group consisting of alkoxy, phenoxy, amino, hydroxyl, and allyl groups is not

particularly limited.

[0051]

Each of R^3 and R^5 is preferably a phenoxy group, more preferably the group represented by the formula (3) since this case results in giving, to the resin sheet, good flame retardancy and good strength after the resin sheet is cured.

[0052]

Examples of the alkoxy group that the bivalent organic group for R^4 has include methoxy, ethoxy, n-propoxy, isopropoxy, n-butoxy, and t-butoxy groups. Particularly preferred are alkoxy groups each having 4 to 10 carbon atoms.

[0053]

The phenoxy group that the bivalent organic group for R^4 has is, for example, the group represented by the formula (3).

[0054]

The symbol y represents an integer of 3 to 25, and is preferably 3 to 10 since this case results in giving, to the resin sheet, good flame retardancy and good strength after the resin sheet is cured.

[0055]

The symbol z represents an integer of 3 to 25, and is preferably 3 to 10 since this case results in giving, to the resin sheet, good flame retardancy and good strength after the resin sheet is cured.

[0056]

The content of the element phosphorus contained in the phosphazene-based flame retardant is preferably 12% by weight or more in order that the flame retardant can produce a flame retardant effect even in a small quantity.

[0057]

The content of the flame retardant component in the resin sheet 11 is preferably 10% by weight or more, more preferably 15% by weight or more of the entire organic components therein. When the content is 10% by weight or more, the resin sheet 11 can gain good flame retardancy. The content of the thermoplastic resin in the resin sheet 11 is preferably 30% by weight or less, more preferably 25% by weight or less of the entire organic components. When the content is 30% by weight or less, a decline in physical properties of the cured product (specifically, a decline in physical properties such as the glass transition temperature or high-temperature resin strength thereof) tends to be small.

[0058]

The resin sheet 11 preferably contains a silane coupling agent. The silane coupling agent is not particularly limited. An example thereof is 3-glycidoxypropyltrimethoxysilane.

[0059]

The content of the silane coupling agent in the resin sheet 11 is preferably 0.1 to 3% by weight. When the content is 0.1% by weight or more, the resin sheet can be heightened,

after cured, in hardness and further decreased in water absorption percentage. In contrast, when the content is 3% by weight or less, the generation of outgas can be restrained.

[0060]

The resin sheet 11 preferably contains a pigment. The pigment is not particularly limited. An example thereof is carbon black.

[0061]

The content of the pigment in the resin sheet 11 is preferably 0.1 to 2% by weight. When the content is 0.1% by weight or more, the resin sheet can gain good marking performance. In contrast, when the content is 2% by weight or less, the resin sheet can ensure strength after cured.

[0062]

Besides the above-mentioned individual components, other additives may be appropriately blended with the resin composition as required.

[0063]

Before the resin sheet 11 is cured, the dynamic viscosity of the resin sheet 11 at 80°C ranges preferably from 5000 to 30000 Pa·s both inclusive, more preferably from 7000 to 25000 Pa·s both inclusive, even more preferably from 10000 to 20000 Pa·s both inclusive. By setting the dynamic viscosity of the resin sheet 11 within the above-mentioned range, the following are efficiently made compatible with each other: sure retention

of the hollow structure; and the property of the sheet that follows irregularities in portions other than the hollow structure.

[0064]

[Production method for a hollow sealing resin sheet]

A method for producing the resin sheet 1 is not particularly limited. The method is preferably a method of preparing a kneaded product, and processing the resultant kneaded product into a sheet form. Specifically, the above-mentioned individual components are melt-kneaded using a known kneading machine such as a mixing roll, a pressure kneader, or an extruder to prepare a kneaded product, and then processing the resultant kneaded product into a sheet form. Kneading conditions are not particularly limited as long as the temperature is equal to or higher than the softening points of the components described above, and the temperature is, for example, 30 to 150°C, and preferably 40 to 140°C, further preferably 60 to 120°C when considering the heat-curability of the epoxy resin, and the time is, for example, 1 to 30 minutes, preferably 5 to 15 minutes.

[0065]

The kneading is preferably performed under a reduced pressure condition (in a reduced pressure atmosphere). The upper limit of the pressure under the reduced pressure condition is preferably 0.1 kg/cm² or less, more preferably 0.05 kg/cm²

or less. As the lower limit of the pressure under the reduced pressure condition is lower, a more preferred result is obtained. However, the lower limit may be 1×10^{-4} kg/cm² or more from the viewpoint of the productivity and physical limit. Such a pressure makes it possible to prevent gas from being blended into the kneaded product to restrain the generation of pores in the resultant kneaded product.

[0066]

It is preferred that the kneaded product after the melt-kneading is processed while kept in a high temperature state without being cooled. The method for the processing is not particularly limited. Examples thereof include a flat-plate pressing method, a T-die extrusion method, a rolling method, a roll kneading method, an inflation extrusion method, a co-extrusion method, and a calendering method. The processing temperature is preferably not lower than the respective softening points of the above-mentioned individual components. Considering the thermosetting property and the moldability of the epoxy resin, the processing temperature is, for example, 40 to 150°C, preferably 50 to 140°C, even more preferably 70 to 120°C.

[0067]

The thickness of the resin sheet 11 is not particularly limited, and is preferably 100 to 2000 μm. When the thickness is in the above-mentioned range, an electronic device can be

satisfactorily sealed up. Additionally, the resin sheet is made thin, whereby the quantity of generated heat can be decreased, so that the resin sheet does not easily undergo curing shrinkage. As a result, the resultant package can be decreased in warp quantity to be obtained as a hollow package higher in reliability.

[0068]

The resin sheet 11 may have a monolayer structure, or a multilayer structure in which two or more resin sheets are laminated onto each other. The monolayer structure is preferred since interlayer delamination is not caused, the sheet thickness is high in uniformity, and the resin sheet is easily made low in hygroscopicity.

[0069]

The resin sheet 11 is used to seal electronic devices, such as a SAW (surface acoustic wave) filter; MEMS (micro electro mechanical systems), such as a pressure sensor and a vibration sensor; a semiconductor in an IC such as an LSI, or in a transistor; a capacitor; a resistor; and/or a CMOS sensor. The resin sheet 11 is usable preferably for sealing electronic devices for which hollow sealing is required (specifically, a SAW filter or MEMS), and is usable in particular preferably for sealing a SAW filter.

[0070]

[Production method for a hollow package]

Figs. 2A to 2C are each a drawing that schematically illustrates a step of a method according to one embodiment of the present invention for producing a hollow package. The manner therein for hollow sealing is not particularly limited. Thus, the hollow sealing can be achieved in a manner known in the prior art. The manner is, for example, a manner of laminating (or putting) an uncured resin sheet 11 onto a substrate to cover electronic devices on an adherend while a hollow structure is kept on the substrate, and next curing the resin sheet 11 to seal up the devices. The adherend is not particularly limited, and examples thereof include a printed wiring substrate, a ceramic substrate, a silicon substrate, and a metallic substrate. In the present embodiment, SAW chips 13 mounted on a printed wiring substrate 12 are sealed up with the resin sheet 11 in a hollow state to produce a hollow package.

[0071]

(SAW chip mounting substrate providing step)

In a SAW chip mounting substrate providing step, a printed wiring substrate 12 on which a plurality of SAW chips 13 are mounted is provided (see Fig. 2A). The SAW chips 13 can be formed by dicing a piezoelectric crystal, on which a predetermined comb-shaped electrode is formed, into individual pieces by a known method. For mounting the SAW chips 13 onto the printed wiring substrate 12, a known device such as a flip chip bonder or a die bonder can be used. The SAW chip 13 and

the printed wiring substrate 12 are electrically connected via a protruded electrode 13a such as a bump. A hollow region 14 is maintained between the SAW chips 13 and the printed wiring substrate 12 not so as to hinder the transmission of surface acoustic waves in surfaces of their SAW filters. The distance between the SAW chips 13 and the printed wiring substrate 12 may be appropriately set, and is generally about 10 to 100 μm .

[0072]

(Sealing step)

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

[0073]

The method for laminating the resin sheet 11 onto the printed wiring substrate 12 is not particularly limited, and may be a known method such as hot pressing or a laminator. Conditions in the hot pressing are as follows: the temperature ranges, for example, from 40 to 100°C, preferably from 50 to 90°C; the pressure ranges, for example, from 0.1 to 10 MPa, preferably from 0.5 to 8 MPa; and the period is, for example, from 0.3 to 10 minutes, preferably from 0.5 to 5 minutes. Considering the close adhesion of the resin sheet 11 onto the

SAW chips 13 and the printed wiring substrate 12, and the performance of the sheet that follows the chips and the board, it is preferred to perform the pressing under a reduced pressure condition (for example, 0.1 to 5 kPa).

[0074]

(Sealed body forming step)

In the sealed body forming step, the resin sheet 11 is subjected to thermal curing treatment to form a sealed body 15 (see Fig. 2B). About conditions in the thermal curing treatment, 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 or lower, more preferably 180°C or lower. 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 or shorter, more preferably 120 minutes or shorter. As required, the resin sheet may be pressurized. The pressure is preferably 0.1 MPa or more, more preferably 0.5 MPa or more. The upper limit of the pressure is preferably 10 MPa or less, more preferably 5 MPa or less.

[0075]

(Dicing step)

Subsequently, the sealed body 15 may be diced (see Fig. 2C). This step makes it possible to yield hollow packages 18 separated from one another in the unit of each of the SAW chips 13.

[0076]

(Substrate mounting step)

As required, a substrate mounting step may be performed in which re-wiring and bumps are formed on each of the hollow packages 18, and the resultant is mounted onto another 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 apparatus is usable.

[0077]

<<Second Embodiment>>

In the first embodiment, the individual blend components are kneaded using a kneader or the like to prepare a kneaded product, and then this kneaded product is extruded to be made into a sheet form. By contrast, in the present embodiment, the individual components are dissolved or dispersed in an organic solvent or some other, and then the resultant varnish is applied to be made into a sheet form.

[0078]

As a specific preparation procedure using a varnish, the above mentioned components and other additives as necessary are appropriately mixed in accordance with a usual method, and the mixture is uniformly dissolved or dispersed in an organic solvent to prepare a varnish. Then, the varnish is applied onto a support of polyester or the like, and dried, whereby the hollow sealing resin sheet 11 can be obtained. A release sheet such

as a polyester film may be laminated as necessary for protecting the surface of the hollow sealing resin sheet. The release sheet is peeled off at the time of sealing.

[0079]

The organic solvent is not particularly limited, and various kinds of previously known organic solvents, for example, methyl ethyl ketone, acetone, cyclohexanone, dioxane, diethyl ketone, toluene, ethyl acetate and the like can be used. They may be used alone or in combination of two or more thereof. Normally, it is preferred to use the organic solvent in such a manner that the solid concentration of the varnish ranges from 30 to 95% by weight.

[0080]

The thickness of the sheet after drying of the organic solvent is not particularly limited, but is normally set to preferably 5 to 100 μm , more preferably 20 to 70 μm , from the viewpoint of uniformity of the thickness and the amount of a residual solvent.

EXAMPLES

[0081]

Hereinafter, preferred examples of the present invention will be exemplarily described in detail. About any material, blend amount thereof, and any other that are described in each of these examples, the scope of the present invention is not

limited only thereto unless a description of making a restriction thereabout is made.

[0082]

The following will describe components used in the examples.

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

Phenolic resin: MEH-7851-SS, manufactured by Meiwa Plastic Industries, Ltd. (phenolic resin having a biphenylaralkyl skeleton; hydroxyl equivalent: 203 g/eq., and softening point: 67°C)

Thermoplastic resin: SIBSTER 072T, manufactured by Kaneka Corporation (styrene-isobutylene-styrene block copolymer)

Inorganic filler 1: FB-9454 FC, manufactured by Denki Kagaku Kogyo Kabushiki Kaisha (spherical fused silica; average particle diameter: 20 μm)

Inorganic filler 2: EMIX 300, manufactured by Tatsumori Ltd. (finely-divided silica; specific surface area: 30 m^2/g)

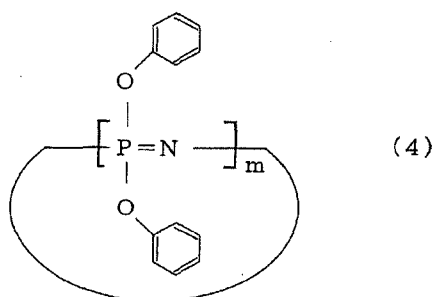
Inorganic filler 3: EMIX 100, manufactured by Tatsumori Ltd. (finely-divided silica; specific surface area: 50 m^2/g)

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

Carbon black: #20, manufactured by Mitsubishi Chemical Corporation

Flame retardant: FP-100, manufactured by FUSHIMI Pharmaceutical Co., Ltd. (phosphazene-based flame retardant: a compound represented by the following formula (4))

[Formula 4]



wherein m represents an integer of 3 to 4.

Curing accelerator: 2PHZ-PW, manufactured by Shikoku Chemicals Corporation

(2-phenyl-4,5-dihydroxymethylimidazole)

[0083]

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

In each of these examples, in accordance with the blend ratio shown in Table 1, individual components were blended with one another, and a roll kneader was used to melt-knead the blend at 60 to 120°C under a reduced pressure condition (0.01 kg/cm²) for 10 minutes to prepare a kneaded product. Next, the resultant kneaded product was made into the form of a sheet by a flat-plate pressing method. In this way, a hollow sealing resin sheet having the thickness shown in Table 1 was produced.

[0084]

[Example 5]

In accordance with the blend ratio shown in Table 1, individual components were dissolved or dispersed in a 1 : 1 mixed solvent of methyl ethyl ketone and toluene to produce a varnish having a solid content of 40% by weight. Next, the varnish was applied to a PET film having been subjected to release treatment to give a coating film thickness of 50 μm after the solvent would be dried. Thereafter, the coating film was dried under the following drying conditions: a temperature of 120°C and a period of 3 minutes. In this way, each resin sheet having a thickness of 50 μm was yielded. A laminator was used to laminate some of the resultant resin sheets onto each other to have a thickness of 200 μm . Thus, a hollow sealing resin sheet having a thickness of 200 μm was produced.

[0085]

(Measurement of the particle diameter distribution of each of the inorganic fillers)

The hollow sealing resin sheet of each of the examples and the comparative examples was put into a crucible, and then intensely heated at 700°C for 2 hours in the air atmosphere to be incinerated. The resultant ash content was dispersed in pure water, and the dispersion was subjected to ultrasonic treatment for 10 minutes. The particle diameter distribution (based on volume) thereof was obtained using a laser diffraction

scattering type particle diameter distribution measuring machine ("LS 13 320," manufactured by Beckman Coulter, Inc.; wet method). About the composition of the hollow sealing resin sheet, others than the inorganic filler were organic components; thus, by the intense heating treatment, substantially all of the organic components were burned out. Thus, under a condition that the resultant ash content was regarded as the inorganic filler, the measurement was made. The results are shown in Table 1.

[0086]

Fig. 3 shows a frequency distribution curve obtained by the particle diameter distribution measurement of the inorganic filler in the hollow sealing resin sheet of Example 3. From Fig. 3, it is understood that in the inorganic filler in Example 3, a single frequency distribution peak was present in each of a particle diameter range from 1 to 10 μm both inclusive, and a particle diameter range more than 10 μm and not more than 100 μm .

[0087]

(Measurement of the dynamic viscosity of each of the hollow sealing resin sheets)

The dynamic viscosity of each of the hollow sealing resin sheets was measured at 80°C before the sheet was thermally cured. The following was rendered the dynamic viscosity: a value obtained by measurement according to a parallel plate method

using a viscoelasticity measuring instrument "ARES" manufactured by TA Instruments. In more detail, the viscosity was measured in a range from 50 to 200°C under the following conditions: a gap of 100 μm , a rotary plate diameter of 20 mm, and a rotary velocity of 10 s^{-1} . The viscosity at 80°C that was obtained at this time was defined as the dynamic viscosity. The results are shown in Table 1.

[0088]

(Measurement of the BET specific surface area of each of the inorganic fillers)

The BET specific surface area was measured by a BET adsorption method (multipoint method). Specifically, the ash content obtained in the item "Measurement of the particle diameter distribution of each of the inorganic fillers" was vacuum-deaerated at 110°C for 6 hours or longer using a quadruple type specific surface area/pore distribution measuring machine "NOVA-4200e model" manufactured by Quantachrome, and then the ash content was measured at a temperature of 77.35 K in a nitrogen gas.

[0089]

(Evaluation of the resin entry property into a hollow region of each package, and the aggregation of its inorganic filler)

In each of the examples, SAW chips each having aluminum comb-shaped electrodes formed therein and having the following specification were mounted onto a glass substrate under bonding

conditions described below to produce a SAW chip mounted substrate. In each of Examples 1 to 3 and 5 and Comparative Examples 1 and 2, the gap width between the SAW chips and the glass substrate was 30 μm . In Example 4, the width was 90 μm .

[0090]

<SAW chips>

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

Bump material (Examples 1 to 3 and 5, and Comparative Examples 1 to 2): Au (height: 30 μm)

Bump material (Example 4): solder (lead-free type)
(height: 90 μm)

Number of bumps: six

Number of chips: 100 (10 $\times$ 10)

[0091]

<Bonding conditions>

Device: manufactured by Panasonic Corporation

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

[0092]

The respective hollow sealing resin sheets were attached onto the resultant SAW chips mounted substrates by vacuum pressing under heating and pressurizing conditions described below.

[0093]

<Attaching conditions>

Temperature: 60°C

Pressurizing force: 4 MPa

Vacuum degree: 1.6 kPa

Pressing period: 1 minute

[0094]

The machine for the vacuum pressing was released into the atmospheric pressure. Thereafter, in a hot-wind drier, each of the laminates was put into a condition of a temperature of 150°C for 1 hour to cure the hollow sealing resin sheet thermally to yield a sealed body. From the glass substrate side thereof, through an electronic microscope (trade name: "DIGITAL MICROSCOPE," manufactured by KEYENCE CORPORATION; magnifying power: 200), the entry quantity of the resin into the hollow region between the SAW chips and the glass substrate was measured. About the resin entry quantity, before the sealing with the hollow sealing resin sheet, the position of the end of the SAW chips was identified from the glass substrate side through the electronic microscope, and then memorized. After the sealing, the chips were again observed from the glass substrate side through the electronic microscope. Before and after the sealing, the observed images were compared with each other, and then a measurement was made about the maximum arrival distance of the resin that entered the hollow region from the SAW chip end identified before the sealing. This distance was defined as the resin entry quantity. When the resin entry

quantity was 20 μm or less, the resin sheet was judged to be "O". Alternatively, when the quantity was more than 20 μm , the resin sheet was judged to be "x".

[0095]

About the aggregation of the inorganic filler, when no aggregate was visually recognized in any one of the hollow sealing resin sheets and further a good irregularity-following property at the time of the sealing was obtained by observing the sheet through a microscope at a magnifying power of 50, the sheet was judged to be "O". Alternatively, when one or more aggregates were visually recognized in any one of the hollow sealing resin sheets and further a good irregularity-following property at the time of the sealing was not obtained by observing the sheet through a microscope at a magnifying power of 50, the sheet was judged to be "x". About the evaluation of the irregularity-following property, each of the produced sealing sheets was cut with a cutter, and one of the cut surfaces was polished using an automatic polishing machine manufactured by Buehler. After the polishing, the cut surface was observed through a microscope. Whether or not a gap was present between the hollow sealing resin sheet and the substrate or chips was used as a criterion for judging whether the resin sheet was good or not. Results of respective evaluations of the resin entry property and the aggregation are shown in Table 1.

[0096]

[Table 1]

		Example 1	Example 2	Example 3	Example 4	Example 5	Comparative Example 1	Comparative Example 2
Blend ratio (part(s) by weight)	Epoxy resin	3.3	3.3	3.3	3.3	3.3	5.6	3.3
	Phenolic resin	3.5	3.5	3.5	3.5	3.5	5.8	3.5
	Thermoplastic resin	3.0	3.0	3.0	3.0	3.0	5.0	3.0
	Inorganic filler 1	88.0	87.0	86.0	85.0	88.0	80.0	83.0
	Inorganic filler 2	-	1.0	-	3.0	-	-	5.0
	Inorganic filler 3	-	-	1.0	-	-	-	-
	Silane coupling agent	0.3	0.3	0.3	0.3	0.3	0.5	0.3
	Carbon black	0.3	0.3	0.3	0.3	0.3	0.5	0.3
	Flame retardant	1.5	1.5	1.5	1.5	1.5	2.4	1.5
	Curing accelerator	0.1	0.1	0.1	0.1	0.1	0.2	0.1
Production method		Kneading	Kneading	Kneading	Kneading	Coating	Kneading	Kneading
Sheet thickness [μm]		200	200	200	200	200	200	200
Evaluation	Inorganic filler content [% by volume]	80	80	80	80	80	69	80
	BET specific surface area [m^2/g] of inorganic filler	3.3	3.6	3.9	4.7	3.3	1.9	5.2
	Sheet dynamic viscosity [$\text{Pa}\cdot\text{s}$] (at 80°C)	12000	12500	12800	25000	11500	4000	40000
	Particle diameter distribution	Number of peak(s) in range from 1 to 10 μm (both inclusive)		1	1	1	1	1
		Number of peak(s) in range more than 10 μm and not more than 100 μm		1	1	1	1	1
	Resin entry into hollow region	Gap width [μm]		30	30	30	30	30
		Entry quantity [μm]		10	7	5	19	12
		Judgment		O	O	O	O	x
	Aggregation of inorganic filler		O	O	O	O	O	x

[0097]

As is understood from Table 1, in each of the SAW chip packages of Examples 1 to 5, the resin component of the hollow sealing resin sheet was restrained from entering its hollow region. Thus, it is understood that such an example makes it possible to produce a hollow package with high quality even when its hollow region is enlarged. In Comparative Example 1, the resin entry quantity into its hollow region was more than 20 μm . In Comparative Example 2, the inorganic filler aggregated, and at the time of the sealing, the irregularity-following property was poor. Thus, Comparative Example 2 failed to be evaluated about the resin entry property to the hollow region.

DESCRIPTION OF REFERENCE SIGNS

[0098]

- 11: Hollow sealing resin sheet
- 11a: Support
- 13: SAW chip
- 15: Sealed body
- 18: Hollow package

CLAIMS

1. A hollow sealing resin sheet, comprising a thermoplastic resin and an inorganic filler in a content of
5 70 to 90% by volume both inclusive, wherein:

in a particle diameter distribution of the inorganic filler that is measured by a laser diffraction scattering method, at least one frequency distribution peak is present in the particle diameter range of 1 to 10 μm both
10 inclusive, and further at least one frequency distribution peak is present in the particle diameter of range more than 10 μm and not more than 100 μm ; and

the inorganic filler has a BET specific surface area of 2 to 5 m^2/g both inclusive.

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2. The hollow sealing resin sheet according to claim 1, which has a dynamic viscosity of 5000 to 30000 Pa·s both inclusive at 80°C before cured.

20 3. The hollow sealing resin sheet according to claim 1 or 2, wherein the inorganic filler is silica particles, alumina particles, or a mixture of these particles.

4. The hollow sealing resin sheet according to any
25 one of claims 1 to 3, wherein the inorganic filler is spherical.

5. A production method for a hollow package, comprising:
a laminating step of laminating the hollow sealing resin sheet recited in any one of claims 1 to 4 over one or more electronic devices arranged on an adherend to cover the electronic devices while a hollow region is maintained between the adherend and the electronic devices; and
a sealed body forming step of curing the hollow sealing resin sheet to form a sealed body.