

DESCRIPTION

TITLE OF THE INVENTION: RESIN SHEET FOR HOLLOW ELECTRONIC DEVICE
ENCAPSULATION AND METHOD FOR MANUFACTURING HOLLOW ELECTRONIC
DEVICE PACKAGE

TECHNICAL FIELD

[0001]

The present invention relates to a hollow electronic device sealing resin sheet, and a method for manufacturing a hollow electronic device package.

BACKGROUND ART

[0002]

As a method for manufacturing a hollow electronic device package in which a hollow electronic device, such as a SAW (surface acoustic wave) filter, is sealed with a resin, the following method has been hitherto known: a method in which a hollow electronic device fixed to a substrate is sealed with a thermosetting resin sheet (see, for example, Patent Document 1).

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0003]

Patent Document 1: JP-A-2006-19714

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0004]

It is important for any hollow electronic device package to secure, therein, a hollow region, and be restrained from being warped.

[0005]

An object of the present invention is to solve the problem to provide a hollow electronic device sealing resin sheet that can secure a hollow region of a hollow electronic device package and that can restrain the hollow electronic device package from being warped, and a hollow electronic device package.

MEANS FOR SOLVING THE PROBLEMS

[0006]

The present invention relates to a hollow electronic device sealing resin sheet, including a first resin layer and a second resin layer, the first and second resin layers each containing a filler, and the resin sheet satisfying the following expressions (1) and (2):

"content (% by volume) of the filler in the first resin layer" < "content (% by volume) of the filler in the second resin layer" (1); and

"viscosity of the first resin layer" > "viscosity of the

second resin layer" (2).

[0007]

The content of the filler in the second resin layer 2 is larger than the content of the filler in the first resin layer 1; therefore, the second resin layer 2 can be caused to take charge of restraining a package of the hollow electronic device from being warped. Moreover, the viscosity of the first resin layer 1 is higher than the viscosity of the second resin layer 2; therefore, the first resin layer 1 can be restrained from invading a hollow region of the hollow electronic device package.

[0008]

It is preferred that the ratio of viscosity of the first resin layer to viscosity of the second resin layer (the value of "first resin layer viscosity"/"second resin layer viscosity") is from 3 to 1000.

[0009]

It is preferred that the ratio of tensile storage elastic modulus of the first resin layer to tensile storage elastic modulus of the second resin layer (the value of "first resin layer tensile storage elastic modulus"/"second resin layer tensile storage elastic modulus") is from 5 to 500.

[0010]

It is preferred that the ratio of average particle diameter of the filler in the first resin layer to average

particle diameter of the filler in the second resin layer (the value of "average particle diameter of the filler in the first resin layer"/"average particle diameter of the filler in the second resin layer") is from 0.01 to 0.5.

[0011]

It is preferred that the content of the filler in the first resin layer is 69% by volume or less, and the content of the filler in the second resin layer is more than 69% by volume.

[0012]

It is preferred that the ratio of thickness of the first resin layer to thickness of the second resin layer (the value of "first resin layer thickness"/"second resin layer thickness") is from 0.05 to 0.3.

[0013]

It is preferred that the viscosity of the first resin layer is 10000 Pa·s or more.

[0014]

The present invention also relates to a method for manufacturing a hollow electronic device package, including the step of providing the above-mentioned hollow electronic device sealing resin sheet; the step of providing a substrate on which a hollow electronic device is to be mounted; and the step of laminating the hollow electronic device sealing resin sheet on the substrate to bring the first resin layer into contact with the hollow electronic device and the substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Fig. 1 is a schematic sectional view of a resin sheet of Embodiment 1.

Fig. 2 is a schematic sectional view of a printed wiring board on which SAW filters are mounted.

Fig. 3 is a drawing that schematically illustrates a situation that the SAW filters are sealed with the resin sheet of Embodiment 1.

Fig. 4 is a drawing that schematically illustrates a situation that a SAW filter package is diced.

Fig. 5 is a drawing that schematically illustrates a situation that a chip-form SAW filter package is mounted on a substrate.

Fig. 6 is a drawing that schematically illustrates a situation that the shear adhering strength of a sample is measured.

MODE FOR CARRYING OUT THE INVENTION

[0016]

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

[0017]

[Embodiment 1]

Fig. 1 is a schematic sectional view of a resin sheet 11 of Embodiment 1. The resin sheet 11 has a structure in which a first resin layer 1 and a second resin layer 2 are laminated on each other. Supports, such as polyethylene terephthalate (PET) films, may be laid on both surfaces of the resin sheet 11. Release treatment may be applied to the supports in order that the supports can easily be peeled off from the resin sheet 11.

[0018]

The resin sheet 11 satisfies the following expressions (1) and (2):

"content (% by volume) of the filler in the first resin layer 1" < "content (% by volume) of the filler in the second resin layer 2" (1); and

"viscosity of the first resin layer 1" > "viscosity of the second resin layer 2" (2).

[0019]

The filler in the second resin layer 2 is larger in content than the filler in the first resin layer 1 to make it possible to cause the second resin layer 2 to take charge of restraining a hollow electronic device package from being warped. Moreover, the first resin layer 1 is higher in viscosity than the second resin layer 2 to make it possible to restrain the first resin layer 1 from invading a hollow region of the hollow electronic

device package.

[0020]

The ratio of viscosity of the first resin layer 1 to viscosity of the second resin layer 2 (the value of "first-resin-layer-1 viscosity"/"second-resin-layer-2 viscosity") is preferably 3 or more, more preferably 10 or more. When the ratio is 3 or more, the resin sheet can secure hollow-forming performance. The ratio of viscosity of the first resin layer 1 to viscosity of the second resin layer 2 is preferably 1000 or less, more preferably 500 or less. When the ratio is 1000 or less, the resin is good in embeddability in the hollow electronic device. In other words, when the package is formed, voids involved therein can be excluded.

[0021]

The ratio of tensile storage elastic modulus of the first resin layer 1 to tensile storage elastic modulus of the second resin layer 2 (the value of "first-resin-layer-1 tensile storage elastic modulus"/"second-resin-layer-2 tensile storage elastic modulus") is preferably 5 or more, more preferably 10 or more. When the ratio is 5 or more, the resin sheet 11 is not excessively soft to be good in handleability. The ratio of tensile storage elastic modulus of the first resin layer 1 to tensile storage elastic modulus of the second resin layer 2 is preferably 500 or less, more preferably 300 or less. When the ratio is 500 or less, the resin sheet 11 can be prevented

from being cracked or chipped when handled.

[0022]

It is preferred that the filler in the second resin layer 2 is larger in average particle diameter than the filler in the first resin layer 1. By raising the proportion of the filler filled into the second resin layer 2, the electronic device package can be heightened in reliability. Moreover, this matter is also effective for decreasing the warp.

[0023]

For example, the ratio of average particle diameter of the filler in the first resin layer 1 to average particle diameter of the filler in the second resin layer 2 (the value of "average particle diameter of the filler in the first resin layer 1"/"average particle diameter of the filler in the second resin layer 2") is preferably 0.01 or more, more preferably 0.1 or more. When the ratio is 0.01 or more, the sealing sheet 11 can be designed with both of high reliability and hollow-forming performance. The ratio of average particle diameter of the filler in the first resin layer 1 to average particle diameter of the filler in the second resin layer 2 is preferably 0.5 or less, more preferably 0.4 or less. When the ratio is 0.5 or less, the layers are good in tackiness therebetween so that the layers can be prevented from being peeled off from each other.

[0024]

It is preferred that the ratio of thickness of the first

resin layer 1 to thickness of the second resin layer 2 (the value of "first-resin-layer-1 thickness"/"second-resin-layer-2 thickness") is preferably 0.05 or more. When the ratio is 0.05 or more, in forming the hollow electronic device package, the first resin layer 1 can be prevented from being broken by, for example, its chip edge. The ratio of thickness of the first resin layer 1 to thickness of the second resin layer 2 is preferably 0.3 or less, more preferably 0.15 or less, even more preferably 0.1 or less. When the ratio is 0.3 or less, the hollow electronic device package can be restrained from being warped.

[0025]

Although the first resin layer 1 is smaller in filler content than the second resin layer 2, the first resin layer 1 is higher in viscosity than the second resin layer 2. The highly viscous first resin layer 1 can be obtained, for example, by incorporating a relatively large proportion of an elastomer component in the first resin layer 1. Moreover, the highly viscous first resin layer 1 can be obtained by incorporating a filler smaller in average particle diameter in the first resin layer 1.

[0026]

The elastomer component may be a known material that may be of various types. Examples thereof include a natural rubber, a butyl rubber, an isoprene rubber, a chloroprene rubber, an

ethylene-vinyl acetate copolymer, an ethylene-acrylic acid copolymer, an ethylene-acrylate copolymer, a polybutadiene resin, a polycarbonate resin, a thermoplastic polyimide resin, polyamide resins such as 6-nylon and 6,6-nylon, a phenoxy resin, an acrylic elastomer (acrylic resin), saturated polyester resins such as PET and PBT, a polyamideimide resin, a fluororesin, and a styrene-isobutylene-styrene block copolymer. Out of these examples, an acrylic elastomer is preferred.

[0027]

The acrylic elastomer (acrylic resin) is not limited to any especial kind, and may be, for example, a polymer (acrylic copolymer) comprising, as a component or components, one or more esters of acrylic acid or methacrylic acid having a linear or branched alkyl group having 30 or less carbon atoms, in particular, 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.

[0028]

A different monomer which constitutes the above-mentioned polymer (acrylic copolymer) is not limited to any especial kind, and examples thereof include

carboxyl-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-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) methylacrylate; monomers which contain a sulfonic acid group, such as styrenesulfonic acid, allylsulfonic acid, 2-(meth)acrylamide-2-methylpropanesulfonic acid, (meth)acrylamidepropane sulfonic acid, sulfopropyl (meth)acrylate, and (meth)acryloyloxynaphthalenesulfonic acid; and monomers which contain a phosphoric acid group, such as 2-hydroxyethylacryloyl phosphate.

[0029]

Out of the acrylic resins, an acrylic resin having a weight-average molecular weight of 100000 or more is preferred, one having a weight-average molecular weight of 300000 to 3000000 is more preferred, and one having a weight-average molecular weight of 500000 to 2000000 is even more preferred.

The weight-average molecular weight of the acrylic resin is a value calculated by measuring the acrylic resin through

GPC (gel permeation chromatography) and subjecting the resultant value to conversion in terms of polystyrene.

[0030]

It is preferred that the content of the elastomer component in the first resin layer 1 is relatively large. The content is, for example, preferably 10% by weight or more, more preferably 11% by weight or more. When the content is 10% by weight or more, the first resin layer 1 can be heightened in viscosity to be restrained from invading the hollow region of the hollow electronic device package. In the meantime, the content of the elastomer component in the first resin layer 1 is preferably 50% by weight or less, more preferably 20% by weight or less. When the content is 50% by weight or less, the resin becomes high in hardness and strength after thermal curing. Thus, the first resin layer 1 is good in reliability for the package.

[0031]

The first resin layer 1 contains a filler.

[0032]

The filler is not particularly limited, and is preferably an inorganic filler. Examples of the inorganic filler include quartz glass, talc, silica species (such as fused silica and crystalline silica), alumina, aluminum nitride, silicon nitride, and boron nitride. Out of these examples, silica species and alumina are preferred, and silica species are more

preferred, since these species are capable of advantageously reducing the linear expansion coefficient. Out of the silica species, fused silica is preferred, and spherical fused silica is more preferred since the silica is excellent in fluidity.

[0033]

The average particle diameter of the filler is preferably 0.1 μm or more, more preferably 0.5 μm or more, even more preferably 1 μm or more. When the average particle diameter is 0.1 μm or more, the filler is good in dispersibility in any different organic composition so that a uniform composition is easily obtained. The average particle diameter of the filler is preferably 15 μm or less, more preferably 10 μm or less. When the average particle diameter is 15 μm or less, the thickness of the first resin layer 1 can be made small. Furthermore, the viscosity of the first resin layer 1 can easily be heightened.

The average particle diameter of particles can be derived, for example, by using a sample extracted at will from a population thereof, and measuring the sample by use of a laser diffraction scattering type particle size distribution measuring instrument.

[0034]

The content of the filler in the first resin layer 1 is preferably 69% by volume or less, more preferably 62% by volume or less. When the content is 69% by volume or less, the resin sheet is good in performance of following (or following

irregularities of) the hollow electronic device. In the meantime, the content of the filler is preferably 35% by volume or more, more preferably 45% by volume or more. When the content is 35% by volume or more, the resultant resin sheet can gain good hollow-forming performance.

[0035]

The content of the filler can also be described using, as a unit thereof, the unit "% by weight." Typically, the content of silica will be described using, as a unit thereof, the unit "% by weight."

Silica usually has a specific gravity of 2.2 g/cm^3 ; thus, a preferred range of the content (% by weight) of silica is, for example, as follows:

The content of silica in the first resin layer 1 is preferably 80% by weight or less, more preferably 75% by weight or less. The content of silica in the first resin layer 1 is preferably 50% by weight or more, more preferably 60% by weight or more.

A filler content of 69% by volume corresponds to 80% by weight.

[0036]

Alumina usually has a specific gravity of 3.9 g/cm^3 ; thus, a preferred range of the content (% by weight) of alumina is, for example, as follows:

The content of alumina in the first resin layer 1 is

preferably 88% by weight or less, more preferably 84% by weight or less. The content of alumina in the first resin layer 1 is preferably 64% by weight or more, more preferably 73% by weight or more.

[0037]

The first resin layer 1 preferably contains a thermosetting resin. Examples of the thermosetting resin include an epoxy resin and a phenolic resin. The first resin layer 1 more preferably contains an epoxy resin.

[0038]

The epoxy resin is not particularly limited, and examples thereof include triphenyl methane 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, phenoxy resin, and other various epoxy resins. These epoxy resins may be used alone or in combination of two or more thereof.

[0039]

In order to secure reactivity, the epoxy resin is preferably a resin which has an epoxy equivalent of 150 to 250, and has a softening point or melting point of 50 to 130°C to be solid at room temperature. Out of species of the epoxy resin, more preferred are triphenylmethane type epoxy resin, cresol

novolak type epoxy resin, and biphenyl type epoxy resin from the viewpoint of the reliability of the resin sheet.

[0040]

The first resin layer 1 preferably contains a phenolic resin.

[0041]

The phenolic resin is not particularly limited as far as the resin causes a curing reaction with the epoxy resin. Examples thereof include phenol novolak resin, phenol aralkyl resin, biphenyl aralkyl resin, dicyclopentadiene type phenolic resin, cresol novolak resin, and resol resin. These phenolic resins may be used alone or in combination of two or more thereof.

[0042]

The phenolic resin is preferably a resin having a hydroxyl equivalent of 70 to 250 and a softening point of 50°C to 110°C from the viewpoint of the reactivity thereof with the epoxy resin. The phenolic resin is in particular preferably phenol novolak resin because the resin is high in curing reactivity. Moreover, from the viewpoint of the reliability, the phenolic resin is a low-hygroscopicity phenolic resin such as phenol aralkyl resin, or biphenyl aralkyl resin can be preferably used.

[0043]

The total content of the epoxy resin and the phenolic resin in the first resin layer 1 is preferably 10% by weight or more. When the content is 10% by weight or more, the resin

sheet can gain a good adhering strength to an electronic device, a substrate and others. The total content of the epoxy resin and the phenolic resin in the first resin layer 1 is preferably 50% by weight or less, more preferably 35% by weight or less. When the content is 50% by weight or less, the resin sheet is good in hollow-forming performance.

[0044]

About the blend ratio between the epoxy resin and the phenolic resin, it is preferred from the viewpoint of curing reactivity that the blending is attained to set the total amount of the hydroxyl groups in the phenolic resin in the range of 0.7 to 1.5 equivalents per equivalent of the epoxy groups in the epoxy resin. The total amount is more preferably from 0.9 to 1.2 equivalents.

[0045]

The first resin layer 1 preferably contains a curing accelerator.

[0046]

The curing accelerator is not particularly limited as far as the accelerator advances the curing of the epoxy resin and the phenolic resin. Examples thereof include organic phosphorus compounds such as triphenylphosphine and tetraphenylphosphonium tetraphenylborate; and imidazole compounds such as 2-phenyl-4,5-dihydroxymethylimidazole and 2-phenyl-4-methyl-5-hydroxymethylimidazole.

[0047]

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

[0048]

The first resin layer 1 may appropriately contain blending agents that are other than the above-mentioned components and are generally used to produce a sealing resin. Examples of the agents include a flame retardant component and a silane coupling agent.

[0049]

The first resin layer 1 can be produced by an ordinary production method. For example, the above-mentioned individual components are dissolved or dispersed in a solvent (such as methyl ethyl ketone or ethyl acetate) to prepare a coating liquid, and the coating liquid is applied to a substrate separator. Thereafter, the coating film is dried. In this way, the first resin layer 1 can be produced.

[0050]

The thickness of the first resin layer 1 can be appropriately set in accordance with the height of the hollow region. Since the height of the hollow region is usually from 15 to 50 μm , the thickness of the first resin layer 1 is preferably 15 μm or more, more preferably 20 μm or more. When the thickness is 15 μm or more, the following can be prevented

at the time of forming the hollow electronic device package: the first resin layer 1 is broken so that the second resin layer 2 invades the hollow region. The thickness of the first resin layer 1 is preferably 70 μm or less, more preferably 50 μm or less. When the thickness is 70 μm or less, the thickness of the whole of the resin sheet 11 can be made small so that a thin package can be manufactured.

[0051]

The viscosity of the first resin layer 1 is preferably 10000 Pa·s or more, more preferably 20000 Pa·s or more, even more preferably 200000 Pa·s or more. When the viscosity is 10000 Pa·s or more, the first resin layer 1 can be restrained from invading the hollow region of the hollow electronic device package. The viscosity of the first resin layer 1 is preferably 500000 Pa·s or less, more preferably 300000 Pa·s or less. When the viscosity is 500000 Pa·s or less, the resin sheet can gain good irregularity-following performance.

The viscosity of the first resin layer 1 is measurable by a method described in the item "EXAMPLES."

[0052]

The viscosity of the first resin layer 1 is controllable in accordance with the acrylic resin content, the filler content, and the particle diameter of the filler. The viscosity of the first resin layer 1 can be heightened, for example, by increasing the proportion of the acrylic resin, increasing the

proportion of the filler or decreasing the particle diameter of the filler.

[0053]

The tensile storage elastic modulus of the first resin layer 1 is preferably 2 MPa or more. When the tensile storage elastic modulus is 2 MPa or more, the first resin layer 1 can be restrained from invading the hollow region of the hollow electronic device package. The tensile storage elastic modulus of the first resin layer 1 is preferably 10 MPa or less. When the tensile storage elastic modulus is 10 MPa or less, the resin sheet can gain good irregularity-following performance.

The tensile storage elastic modulus of the first resin layer 1 is measurable by a method described in the item "EXAMPLES."

[0054]

The tensile storage elastic modulus of the first resin layer 1 is controllable in accordance with the filler content, the particle diameter of the filler, the composition and the content of the elastomer component, and the molecular structure and the content of the epoxy resin.

[0055]

The second resin layer 2 contains a filler.

[0056]

The filler is not particularly limited, and is preferably any one of the fillers described about the first resin layer

1.

[0057]

The average particle diameter of the filler blended in the second resin layer 2 is preferably 10 μm or more, more preferably 15 μm or more. When the average particle diameter is 10 μm or more, the proportion of the filled filler can easily be heightened. The average particle diameter of the filler is preferably 40 μm or less, more preferably 20 μm or less. When the average particle diameter is 40 μm or less, the thickness of the resin sheet 11 can be made small so that the resin sheet 11 can be obtained with good surface smoothness.

[0058]

The filler is preferably a filler treated (pretreated) with a silane coupling agent. This case makes it possible to improve the filler in wettability with the resin to heighten the dispersibility of the filler.

[0059]

The silane coupling agent is a compound having a hydrolyzable group and an organic functional group in a molecule.

[0060]

Examples of the hydrolyzable group include alkoxy groups having 1 to 6 carbon atoms such as a methoxy group and an ethoxy group, an acetoxy group, and a 2-methoxyethoxy group. Among these, a methoxy group is preferable because it is easy to remove

a volatile component such as an alcohol generated by hydrolysis.

[0061]

Examples of the organic functional group include a vinyl group, an epoxy group, a styryl group, a methacrylic group, an acrylic group, an amino group, a ureido group, a mercapto group, a sulfide group, an isocyanate group. Among these, an epoxy group is preferable because the epoxy group can easily react with an epoxy resin and a phenolic resin

[0062]

Examples of the silane coupling agent include vinyl group-containing silane coupling agents such as vinyltrimethoxysilane and vinyltriethoxysilane; epoxy group-containing silane coupling agents such as 2-(3,4-epoxycyclohexyl)ethyltrimethoxysilane and 3-glycidoxypropyl methyldimethoxysilane, 3-glycidoxypropyl trimethoxysilane, 3-glycidoxypropyl methyldiethoxysilane, and 3-glycidoxypropyl triethoxysilane; styryl group-containing silane coupling agents such as p-styryltrimethoxysilane; methacrylic group-containing silane coupling agents such as 3-methacryloxypropylmethyldimethoxysilane, 3-methacryloxypropyltrimethoxysilane, 3-methacryloxypropylmethyldiethoxysilane, and 3-methacryloxypropyltriethoxysilane; acrylic group-containing silane coupling agents such as

3-acryloxypropyltrimethoxysilane; amino group-containing silane coupling agents such as N-2-(aminoethyl)-3-aminopropylmethyldimethoxysilane, N-2-(aminoethyl)-3-aminopropyltrimethoxysilane, 3-aminopropyltrimethoxysilane, 3-aminopropyltriethoxysilane, 3-triethoxysilyl-N-(1,3-dimethyl-butylidene)propylamine, N-phenyl-3-aminopropyltrimethoxysilane, and N-(vinylbenzyl)-2-aminoethyl-3-aminopropyltrimethoxysilane; ureido group-containing silane coupling agents such as 3-ureidopropyltriethoxysilane; mercapto group-containing silane coupling agents such as 3-mercaptopropylmethyldimethoxysilane and 3-mercaptopropyltrimethoxysilane; sulfide group-containing silane coupling agents such as bis(triethoxysilylpropyl)tetrasulfide; and isocyanate group-containing silane coupling agents such as 3-isocyanatepropyltriethoxysilane.

[0063]

A method of treating the filler with the silane coupling agent is not especially limited, and examples thereof include a wet method of mixing the filler and the silane coupling agent in a solvent and a dry method of treating the filler with the silane coupling agent in a gas phase.

[0064]

The amount of the silane coupling agent to be used for

the treatment is not especially limited; however, 0.1 to 1 part by weight of the silane coupling agent is preferably used for the treatment to 100 parts by weight of the non-treated filler.

[0065]

The content of the filler in the second resin layer 2 is preferably a value more than 69% by volume, more preferably 71% by volume or more. When the content is more than 69% by volume, the second resin layer 2 can be designed to have a low linear expansion coefficient. In the meantime, the content of the filler is preferably 90% by volume or less, more preferably 85% by volume or less. When the content is 90% by volume or less, the resin sheet can gain softness satisfactorily.

[0066]

The content of the filler can also be described using, as a unit thereof, the unit "% by weight." Typically, the content of silica will be described using, as a unit thereof, the unit "% by weight."

Silica usually has a specific gravity of 2.2 g/cm^3 ; thus, a preferred range of the content (% by weight) of silica is, for example, as follows:

The content of silica in the second resin layer 2 is preferably a value more than 80% by weight, more preferably 82% by weight or more. The content of silica in the second resin layer 2 is preferably 94% by weight or less.

[0067]

Alumina usually has a specific gravity of 3.9 g/cm^3 ; thus, a preferred range of the content (% by weight) of alumina is, for example, as follows:

The content of alumina in the second resin layer 2 is preferably a value more than 88% by weight, more preferably 90% by weight or more. The content of alumina in the second resin layer 2 is preferably 97% by weight or less.

[0068]

The second resin layer 2 preferably contains a thermosetting resin. Examples of the thermosetting resin include an epoxy resin and a phenolic resin. The second resin layer 2 more preferably contains an epoxy resin. The epoxy resin is preferably any one of the epoxy resins described about the first resin layer 1.

[0069]

The second resin layer 2 preferably contains a phenolic resin. The phenolic resin is preferably any one of the phenolic resins described about the first resin layer 1.

[0070]

The total content of the epoxy resin and the phenolic resin in the second resin layer 2 is preferably 2% by weight or more, more preferably 8% by weight or more. When the content is 2% by weight or more, the resultant cured product can gain a sufficient strength. The total content of the epoxy resin and the phenolic resin in the second resin layer 2 is preferably

20% by weight or less, more preferably 15% by weight or less. When the content is 20% by weight or less, the cured product can be made small in linear expansion coefficient and hygroscopicity.

[0071]

About the blend ratio between the epoxy resin and the phenolic resin, it is preferred from the viewpoint of curing reactivity that the blending is attained to set the total amount of the hydroxyl groups in the phenolic resin in the range of 0.7 to 1.5 equivalents per equivalent of the epoxy groups in the epoxy resin. The total amount is more preferably from 0.9 to 1.2 equivalents.

[0072]

The second resin layer 2 preferably contains a thermoplastic resin.

[0073]

Examples of the thermoplastic resin include natural rubber, butyl rubber, isoprene rubber, chloroprene rubber, an ethylene-vinylacetate copolymer, an ethylene-acrylic acid copolymer, an ethylene-acrylate copolymer, a polybutadiene resin, a polycarbonate resin, a thermoplastic polyimide resin, polyamide resins such as 6-nylon and 6,6-nylon, a phenoxy resin, an acrylic resin, saturated polyester resins such as PET and PBT, a polyamideimide resin, a fluoro resin, a styrene-isobutylene-styrene block copolymer, and a

methylethacrylate-butadiene-styrene copolymer (MBS resin). These thermoplastic resins may be used alone or in combination of two or more thereof.

[0074]

The content of the thermoplastic resin in the second resin layer 2 is preferably 1% by weight or more. The content of the thermoplastic resin in the second resin layer 2 is preferably 7% by weight or less, more preferably 5% by weight or less, even more preferably 3.5% by weight or less. When the content is in the range, the resin sheet can gain good flexibility.

[0075]

The second resin layer 2 preferably contains a curing accelerator. The curing accelerator is preferably any one of the curing accelerators described about the first resin layer 1.

[0076]

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

[0077]

The second resin layer 2 may appropriately contain compounding agents that are other than the above-mentioned components and are generally used to produce a sealing resin. This layer may appropriately contain, for example, a flame retardant component, a pigment and/or a silane coupling agent.

[0078]

Examples of the flame retardant component include various kinds of metal hydroxides such as aluminum hydroxide, magnesium hydroxide, iron hydroxide, calcium hydroxide, tin hydroxide, and composite metal hydroxide; and a phosphazene compound. Among these, a phosphazene compound is preferable because it has excellent flame retardance and excellent strength after curing.

[0079]

The pigment is not especially limited, and an example thereof includes carbon black.

[0080]

The method for producing the second resin layer 2 is not particularly limited, and is preferably a method of kneading the above-mentioned individual components (for example, the epoxy resin, the phenolic resin, the thermoplastic resin, the filler and the curing accelerator), and working the resultant kneaded product plastically into a sheet form. This method makes it possible to fill the filler into the layer at a high proportion and design the layer to have a low linear expansion coefficient.

[0081]

Specifically, the epoxy resin, the phenolic resin, the thermoplastic resin, the filler and the curing accelerator are melt-kneaded in a known kneading machine such as a mixing roller,

a pressurizing kneader or an extruder to prepare a kneaded product, and the resultant kneaded product is plastically worked into a sheet form. About conditions for the kneading, the upper limit of the temperature is preferably 140°C or lower, more preferably 130°C or lower. The lower limit of the temperature is preferably not lower than the respective softening points of the individual components and is, for example, 30°C or higher, preferably 50°C or higher. The kneading period is preferably from 1 to 30 minutes. The kneading is preferably performed under a reduced pressure condition (in a reduced pressure atmosphere). The pressure under the reduced pressure condition is, for example, from 1×10^{-4} to 0.1 kg/cm².

[0082]

It is preferred to apply the plastic working to the kneaded product after the melt kneading in the state that the kneaded product keeps a high temperature without being cooled. The method for the plastic working is not particularly limited, and examples thereof include flat plate pressing, T-die extrusion, screw die extrusion, rolling, roll kneading, inflation extrusion, co-extrusion, and calendering methods. The plastic working temperature is preferably not lower than the respective softening points of the above-mentioned individual components, and is, for example, from 40 to 150°C, preferably from 50 to 140°C, more preferably from 70 to 120°C,

considering the thermosetting property and the moldability of the epoxy resin.

[0083]

The thickness of the second resin layer 2 is not particularly limited, and is preferably 100 μm or more, more preferably 150 μm or more. The thickness of the second resin layer 2 is also preferably 2000 μm or less, more preferably 1000 μm or less, even more preferably 300 μm or less. When the thickness is in the range, the resin sheet can restrain the hollow electronic device package from being warped.

[0084]

The viscosity of the second resin layer 2 is preferably 20000 Pa·s or less, more preferably 5000 Pa·s or less. When the viscosity is 20000 Pa·s or less, the hollow electronic device is good in surface smoothness after sealed with the resin sheet.

The viscosity of the second resin layer 2 is measurable by the method described in the item "EXAMPLES."

[0085]

The tensile storage elastic modulus of the second resin layer 2 is preferably 0.02 MPa or more. When the tensile storage elastic modulus is 0.02 MPa or more, the following can be prevented in forming the hollow electronic device package: the resin leaks and flows into the outer circumference of its substrate. The tensile storage elastic modulus of the second resin layer 2 is preferably 0.5 MPa or less. When the tensile

storage elastic modulus is 0.5 MPa or less, the hollow electronic device package is good in smoothness.

The tensile storage elastic modulus of the second resin layer 2 is measurable by the method described in the item "EXAMPLES."

[0086]

The method for producing the resin sheet 11 is not particularly limited, and may be, for example, a method of bonding the first resin layer 1 and the second resin layer 2 on each other, or a method of applying a coating liquid for forming the first resin layer 1 to the second resin layer 2, and then drying the coating liquid.

[0087]

In Fig. 1, a case has been illustrated in which the first resin layer 1 has a monolayered structure. However, the first resin layer 1 is not limited to this case. Thus, the first resin layer 1 may have a multilayered structure. In Fig. 1, a case has been illustrated in which the second resin layer 2 has a monolayered structure. However, the second resin layer 2 is not limited to this case. Thus, the second resin layer 2 may have a multilayered structure.

[0088]

The resin sheet 11 is used to seal a hollow electronic device, which has a hollow structure, examples of the device including SAW (surface acoustic wave) filters and MEMS (micro

electro mechanical systems) such as pressure sensors and vibration sensors. The hollow structure denotes a structure having a hollow between an electronic device and a substrate when the electronic device is mounted on the substrate. The resin sheet 11 is usable suitably, in particular, for sealing a SAW filter.

[0089]

The method for the sealing is not particularly limited. An electronic device can be sealed, for example, by covering the electronic device mounted on a substrate with the resin sheet 11. The substrate is not particularly limited, and is, for example, a printed wiring board, a ceramic substrate, a silicon substrate, a metallic substrate or a semiconductor wafer.

[0090]

[Method for manufacturing Hollow Electronic Device Package]

As a method for manufacturing a hollow electronic device package, the following will describe an example of sealing SAW filters 13 mounted on a printed wiring board 12 with the resin sheet 11 of Embodiment 1 to give hollows, thereby manufacturing SAW filter packages 15 and 16.

[0091]

SAW-Filter-Mounted Substrate Providing Step:

In a SAW-filter-mounted substrate providing step, a printed wiring board 12 is prepared on which a plurality of SAW

filters 13 are mounted (see Fig. 2). The SAW filters 13 can be formed by dicing a piezoelectric crystal in which predetermined comb-shaped electrodes are formed in a known manner to divide the crystal into individual pieces. In order to mount the SAW filters 13 on the printed wiring board 12, a known apparatus such as a flip-chip bonder or a die bonder is usable. The SAW filters 13 are electrically connected to the printed wiring board 12 through projected electrodes 13a such as bumps. Moreover, between the SAW filters 13 and the printed wiring board 12, hollow regions 14 are kept not to hinder the transmission of surface acoustic waves on the SAW filter surface. The distance between each of the SAW filters 13 and the printed wiring board 12 can be appropriately set, and is generally from about 15 to 50 μm .

[0092]

Sealing Step:

In a sealing step, the resin sheet 11 is laminated on the printed wiring board 12 to bring the first resin layer 1 into contact with the printed wiring board 12 and the SAW filters 13, thereby sealing the SAW filters 13 with the resin sheet 11 (see Fig. 3). In this way, a SAW filter package 15 is obtained in which the SAW filters 13 are sealed with the resin.

[0093]

The method for laminating the resin sheet 11 on the printed wiring board 12 is not particularly limited, and the

lamination can be attained by a known means, such as hot pressing or a laminator. About conditions for the hot pressing, the temperature is, for example, from 40 to 100°C, preferably from 50 to 90°C, the pressure is, 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. The pressing is preferably performed under a reduced pressure (of, for example, 0.1 to 5 kPa), considering an improvement in the tackiness of the resin sheet 11 to the SAW filters 13 and the printed wiring board 12 and the performance of the resin sheet 11 that the sheet 11 follows these members 12 and 13.

[0094]

Thermal Curing Step:

As required, the resin sheet 11 for the SAW filter package 15 is thermally cured.

[0095]

About conditions for 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 11 may be pressured. The pressure is preferably 0.1 MPa or more,

more preferably 0.5 MPa or more. The upper limit thereof is preferably 10 MPa or less, more preferably 5 MPa or less.

[0096]

Dicing Step:

As required, the SAW filter package 15 is diced (see Fig. 4). In this way, SAW filter packages 16 that are each in a chip form can be obtained.

[0097]

Mounting-to-substrate Step:

As required, re-interconnections and bumps 17 are formed on the SAW filter package 15 or each of the SAW filter packages 16. The resultant is mounted on a substrate 18 (see Fig. 5).

[0098]

Modified Examples:

In Embodiment 1, the resin sheet 11 has been described, which has the first resin layer 1, and the second resin layer 2 laid on the first resin layer 1. In Modified Example 1, a resin sheet has a first resin layer 1, a third layer laid on the first resin layer 1, and a second resin sheet 2 laid on the third layer. In Modified Example 2, a resin sheet has a first resin layer 1, a second resin layer 2 laid on the first resin layer 1, and a third layer laid on the second resin layer 2. The third layer is preferably, for example, a resin-containing layer or a metallic layer. The third layer may have a monolayered or multilayered structure.

EXAMPLES

[0099]

Hereinafter, preferred examples of this invention will be illustratively described in detail. However, about materials, blended amounts and others that are described in the examples, the scope of this invention is not limited only to these described matters unless the specification especially includes a restrictive description thereabout.

[0100]

A description is firstly made about components used in the examples.

Components used to produce a first resin layer are described in the following.

Epoxy resin 1: YL-980 (bisphenol A type liquid epoxy resin; epoxy equivalent: 185 g/eq.) manufactured by Mitsubishi Chemical Corporation

Epoxy resin 2: EPPN-501HY (epoxy equivalent: 169 g/eq., and softening point: 60°C) manufactured by Nippon Kayaku Co., Ltd.

Epoxy resin 3: 1001 (bisphenol A type; epoxy equivalent: 470 g/eq., and softening point: 64°C) manufactured by Mitsubishi Chemical Corporation

Phenolic resin: GS-180 (phenol novolak type phenolic resin; phenolic hydroxyl equivalent: 105 g/eq., and softening

point: 83°C) manufactured by Gunee Chemical Industry Co., Ltd.

Acrylic resin: TEISAN RESIN SG-70L (Mw: 900000)

manufactured by Nagase Chemtex Corporation

Inorganic filler 1: FB-5SDC (spherical fused silica; average particle diameter: 5 μ m) manufactured by Denka Co., Ltd.

Inorganic filler 2: SO-25R (spherical fused silica; average particle diameter: 0.5 μ m) manufactured by Admatechs Co., Ltd.

Inorganic filler 3: FB-7SDC (spherical fused silica; average particle diameter: 7 μ m) manufactured by Denka Co., Ltd.

Curing accelerator: 2PHZ-PW

(2-phenyl-4,5-dihydroxymethylimidazole) manufactured by Shikoku Chemicals Corporation

[0101]

Components used to produce a second resin layer are described in the following.

Epoxy resin 1: YSLV-80XY (bisphenol F type epoxy resin; epoxy equivalent: 200 g/eq., and softening point: 80°C) manufactured by Nippon Steel Chemical Co., Ltd.

Epoxy resin 2: EPPN-501HY (epoxy equivalent: 169 g/eq., and softening point: 60°C) manufactured by Nippon Kayaku Co., Ltd.

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

Ltd.

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

Inorganic filler 1: FB-9454FC (spherical fused silica;
average particle diameter: 20 μm) manufactured by Denka Co.,
Ltd.

Inorganic filler 2: SE-40 (spherical fused silica;
average particle diameter: 38 μm) manufactured by Tokuyama
Corporation

Inorganic filler 3: FB-570 (spherical fused silica;
average particle diameter: 16 μm) manufactured by Denka Co.,
Ltd.

Inorganic filler 4: FB-5SDC (spherical fused silica;
average particle diameter: 5 μm) manufactured by Denka Co., Ltd.

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

Carbon black: #20 manufactured by Mitsubishi Chemical
Corporation

Flame retardant: FP-100 (phosphazene compound)
manufactured by FUSHIMI Pharmaceutical Co., Ltd.

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

[0102]

[Examples 1 to 5 and Comparative Examples 1 to 2]

Production of Each First Resin Layer:

In each of the examples, individual components were blended with one another in accordance with blend proportions described in Table 1. Thereto was added methyl ethyl ketone in an amount equal to the total amount of the individual components to prepare a vanish. A comma coater was used to apply the resultant vanish to a release-treated surface of a 50 μm -thick polyester film A (MRF-50, manufactured by Mitsubishi Chemical Corporation), and then the resultant was dried. Next, a release-treated surface of a 38 μm -thick polyester film B (MRF-38, manufactured by Mitsubishi Chemical Corporation) was bonded to the dried vanish to produce a first resin layer.

[0103]

[Table 1]

(First resin layer)

	Example 1	Example 2	Example 3	Example 4	Example 5	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4
Epoxy resin 1	3.7	11.7	2.0	3.7	4.0	11.5	11.5	3.7	-
Epoxy resin 2	3.7	5.0	-	3.7	4.0	11.5	11.5	3.7	-
Epoxy resin 3	-	-	8.0	-	-	-	-	-	-
Phenolic resin	4.6	10.5	4.5	4.6	5.0	14.3	14.3	4.6	-
Acrylic resin	12.5	12.1	15.0	12.5	13.5	12.0	12.0	12.5	-
Inorganic filler 1	75.0	60.0	-	-	73.0	-	-	75.0	-
Inorganic filler 2	-	-	70.0	-	-	-	-	-	-
Inorganic filler 3	-	-	-	75.0	-	50.0	50.0	-	-
Curing accelerator	0.5	0.7	0.5	0.5	0.5	0.7	0.7	0.5	-
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	-
Filler content (% by volume) in first resin layer	62	45	56	62	60	35	35	62	-

[0104]

Production of Each Second Resin Layer:

Individual components were blended with one another in accordance with blend proportions described in Table 2. A roll kneader was used to melt and knead the blend at 60 to 120°C under a reduced pressure (0.01 kg/cm^2) for 10 minutes to prepare a kneaded product. Next, the resultant kneaded product was shaped into a sheet form by a flat plate pressing method to produce a second resin layer.

[0105]

[Table 2]

(Second resin layer)

Blend proportions (part(s) by weight)	Example 1	Example 2	Example 3	Example 4	Example 5	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4
	1	2	3	4	5	Example 1	Example 2	Example 3	Example 4
Epoxy resin 1	3.8	4.0	4.0	4.0	3.8	4.0	7.0	-	3.8
Epoxy resin 2	1.0	-	-	1.2	1.0	-	-	-	1.0
Phenolic resin	5.0	4.1	4.1	5.4	5.0	4.1	7.2	-	5.0
Thermoplastic resin	4.5	2.9	2.9	4.7	4.5	2.9	6.8	-	4.5
Inorganic filler 1	82.0	86.0	-	-	82.0	86.0	-	-	82.0
Inorganic filler 2	-	-	86.0	-	-	-	-	-	-
Inorganic filler 3	-	-	-	81.0	-	-	-	-	-
Inorganic filler 4	-	-	-	-	-	-	75.0	-	-
Silane coupling agent	0.2	0.3	0.3	0.2	0.2	0.3	0.2	-	0.2
Carbon black	0.30	0.25	0.25	0.30	0.30	0.25	0.30	-	0.30
Flame retardant	3.0	2.3	2.3	3.0	3.0	2.3	3.3	-	3.0
Curing accelerator	0.20	0.15	0.15	0.20	0.20	0.15	0.20	-	0.20
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	-	100.0
Filler content (% by volume) in second resin layer	71	77	77	70	71	77	62	-	71

[0106]

Production of Each Resin Sheet:

The polyester film A of the first resin layer was peeled off, and then a roll laminator was used to laminate the first resin layer on the second resin layer. In this way, a resin sheet was produced in which the first resin layer was laminated on the second resin layer.

[0107]

[Comparative Example 3]

Production of First Resin Layer:

Individual components were blended with one another in accordance with blend proportions described in Table 1. Thereto was added methyl ethyl ketone in an amount equal to the total amount of the individual components to prepare a vanish. A comma coater was used to apply the resultant vanish to a release-treated surface of a 50 μm -thick polyester film A (MRF-50, manufactured by Mitsubishi Chemical Corporation), and then the resultant was dried. Next, a release-treated surface of a 38 μm -thick polyester film B (MRF-38, manufactured by Mitsubishi Chemical Corporation) was bonded to the dried vanish to produce a first resin layer (a resin sheet made only of the first resin layer).

[0108]

[Comparative Example 4]

Production of Second Resin Layer:

Individual components were blended with one another in accordance with blend proportions described in Table 2. A roll kneader was used to melt and knead the blend at 60 to 120°C under a reduced pressure (0.01 kg/cm^2) for 10 minutes to prepare a kneaded product. Next, the resultant kneaded product was shaped into a sheet form by a flat plate pressing method to produce a second resin layer (a resin sheet made only of the second resin layer).

[0109]

[Evaluation]

About the resin sheet of each of the examples, evaluations described below were made. The results are shown in Table 3.

[0110]

Viscosity:

The first resin layer was cut off from the resin sheet to produce a circular test piece having a thickness of 1 mm and a diameter of 20 mm, and then the following measurement was made: a viscoelasticity measuring instrument ARES manufactured by Rheometric Scientific Inc. was used to measure the test piece in the range of 50 to 150°C at a measuring frequency of 0.1 Hz, a strain of 0.1% and a heating rate of 5°C/minute. The complex viscosity (η^*) thereof at 100°C was then read out.

In the same manner as used to measure the first resin layer, the viscosity of the second resin layer was measured.

[0111]

Tensile Storage Elastic Modulus:

The first resin layer was cut off from the resin sheet to produce a test piece having a thickness of 400 μm and having a size of 10 mm $\times$ 35 mm, and then the following measurement was made: a viscoelasticity measuring instrument (RSA II manufactured by TA Instruments) was used to measure the test piece in the range of 20 to 130°C at a measuring frequency of 1 Hz, a strain of 0.05%, a distance of 22.6 mm between its chucks, and a heating rate of 5°C/minute. The tensile storage elastic modulus (G') thereof at 80°C was then read out.

In the same manner as used to measure the first resin layer, the tensile storage elastic modulus of the second resin layer was measured.

[0112]

Inflow Amount:

The resin sheet was laminated on a ceramic substrate in which SAW filters (chip thickness: 200 μm , and bump height: 20 μm) were arranged in a matrix form, and the laminate was vacuum-pressed (ultimate vacuum: 6.65×10^2 Pa) at a temperature of 100°C and a pressure of 300 kPa for 1 minute. The laminate was then exposed to the atmosphere, and then the SAW filter package was allowed to stand in an oven of 130°C for 3 hours to cure the resin sheet. Thereafter, a dicing machine was used to divide the SAW filter package into individual packages. A cross section of any one of the resultant chip-form SAW filter

packages was observed. A measurement was then made about the inflow amount of the resin from the edge of the chip into the hollow region.

In each of Examples 1 to 5 and Comparative Examples 1 to 2, the resin sheet was laminated on the ceramic substrate to bring the first resin layer into contact with the SAW filters and the ceramic substrate.

[0113]

Tackiness to Alumina Substrate (Shear Adhering Strength at Room Temperature):

Production of respective test pieces of Examples 1 to 5 and Comparative Examples 1 to 2:

The resin sheet of each of the examples was punched out into a circle of 3 mm in diameter. A flat plate press of 90°C was used to press and bond the circuit resin sheet to an alumina substrate (thickness: 0.5 mm) to bring the first resin layer of the circular resin sheet into contact with the alumina substrate. Thereafter, the laminate composed of the resin sheet and the alumina substrate was cured in a hot air oven at 150°C for 1 hour to yield a test piece.

Production of respective test pieces of Comparative Examples 3 to 4:

The resin sheet of each of the examples was punched out into a circle of 3 mm in diameter. A flat plate press of 90°C

was used to press and bond the circular resin sheet to an alumina substrate (thickness: 0.5 mm) to bring the resin sheet into contact with the alumina substrate. Thereafter, the laminate composed of the resin sheet and the alumina substrate was cured in a hot air oven at 150°C for 1 hour to yield a test piece.

Measurement:

Fig. 6 is a drawing that schematically illustrates a situation that the shear adhering strength of any sample is measured. As illustrated in Fig. 6, the test piece (laminate composed of a resin sheet 21 and an alumina substrate 22) was set on a heatable sample table 23 to be adsorbed on the table. A testing tool 24 was located up, 0.1 mm apart, from the upper surface of the adherend 22, and then the resin sheet 21 was pushed at a shifting speed of 0.2 mm/s in a direction parallel to the bonded surfaces of the alumina substrate 22 and the resin sheet 21. The load at this time was measured. The measurement was made in the state that the resin sheet 21 had a temperature of 25°C. A scar of the resin of the resin sheet 21 was measured, and the area (mm²) thereof was calculated.

Calculation:

The shear adhering strength was calculated in accordance with the following expression:

$$\text{"Shear load (N)"/"area (mm}^2\text{)" = shear adhering strength (MPa)}$$

The shear adhering strength is preferably 3 MPa or more.

[0114]

Substrate Warp After Resin Sheet Was Cured:

The resin sheet of each of the examples was laminated on an alumina substrate of 7 cm length, 7 cm width and 0.2 mm thickness, and then the laminate was heated and pressured at 90°C and 5 kN for 60 seconds. Thereafter, in an oven, the resin sheet was cured at 150°C for 1 hour, and then left standing to cool to room temperature. A temperature-variable laser three-dimensional measuring instrument (manufactured by T-Teck) was used to measure the respective heights of four corners of the upper surface of the cured product. The height of the highest position thereof was used as the warp amount. The warp amount is preferably 1 mm or less.

In each of Examples 1 to 5 and Comparative Examples 1 to 2, the resin sheet was laminated on the alumina substrate to bring the first resin layer into contact with the alumina substrate.

[0115]

Irregularity-following Performance:

A groove of 0.2 mm depth and 0.2 mm width was made in an alumina substrate, and then the resin sheet of each of the examples was pressed on the groove-made surface of the alumina substrate at a reduced pressure of 15 torr, and at 120°C and an increased pressure of 0.5 MPa for 3 minutes. In this case, the sample was judged to be ⊙ when the resin reached the whole

of the bottom of the groove; the sample, to be O when the resin reached a portion of the bottom of the groove; or the sample, to be x when the resin did not reach the bottom of the groove at all.

In each of Examples 1 to 5 and Comparative Examples 1 to 2, the resin sheet was laminated on the alumina substrate to bring the first resin layer into contact with the alumina substrate.

[0116]

[Table 3]

	Example 1	Example 2	Example 3	Example 4	Example 5	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4
Average particle diameter (μm) of filler in first resin layer	5	5	0.5	7	5	7	7	5	-
Average particle diameter (μm) of filler in second resin layer	21	21	38	16	21	21	5	-	21
Value of "average particle diameter of filler in first resin layer"/"average particle diameter of filler in second resin layer"	0.24	0.24	0.01	0.44	0.24	0.33	1.40	-	-
First resin layer thickness (μm)	20	25	15	50	20	20	50	220	-
Second resin layer thickness (μm)	200	195	205	170	200	200	170	-	220
Value of "first resin layer thickness"/"second resin layer thickness"	0.10	0.13	0.07	0.29	0.10	0.10	0.29	-	-
First resin layer viscosity (Pa-s) (measuring temperature: 100°C)	420000	14000	70000	205000	420000	1800	1800	420000	-
Second resin layer viscosity (Pa-s) (measuring temperature: 100°C)	450	4500	1100	600	330	4500	6600	-	450
Value of "first resin layer viscosity"/"second resin layer viscosity"	933.3	3.1	63.6	341.7	1272.7	0.4	0.3	-	-
Tensile storage elastic modulus (MPa) (measuring temperature: 80°C) of first resin layer	10.0	2.1	4.8	6.4	10.0	4.8	4.8	10.0	-
Tensile storage elastic modulus (MPa) (measuring temperature: 80°C) of second resin layer	0.022	0.37	0.18	0.031	0.02	0.37	0.37	-	0.022
Value of "tensile storage elastic modulus of first resin layer"/"tensile storage elastic modulus of second resin layer"	454.5	5.7	26.7	206.5	500.0	13.0	13.0	-	-
Invasion amount (μm) of resin into hollow region	5	45	30	23	70	150	90	5	230
Tackiness (MPa) to alumina substrate (shear adhering strength at room temperature)	3.7	5.3	4.7	4.9	3.7	4.2	4.3	3.7	5.1
Substrate warp (mm) after curing of resin sheet	0.4	0.5	0.3	0.9	0.5	2.2	3.9	0.2	1.1
Irregularity-following performance	○	⊙	⊙	○	⊙	⊙	⊙	×	⊙

Evaluations

DESCRIPTION OF REFERENCE SIGNS

[0117]

- 1: First resin layer
- 2: Second resin layer
- 11: Resin sheet
- 12: Printed wiring board
- 13: SAW filter
- 13a: Projected electrode
- 14: Hollow region
- 15, 16: Electronic device packages
- 17: Bump
- 18: Substrate
- 21: Resin sheet
- 22: Alumina substrate
- 23: Sample table
- 24: Testing tool

CLAIMS

1. A hollow electronic device sealing resin sheet,
comprising a first resin layer and a second resin layer,
5 the first and second resin layers each comprising a
filler, and

the resin sheet satisfying the following expressions
(1) and (2):

"content (% by volume) of the filler in the first
10 resin layer" < "content (% by volume) of the filler in the
second resin layer" (1); and

"viscosity of the first resin layer" > "viscosity of
the second resin layer" (2),

wherein the ratio of tensile storage elastic modulus
15 of the first resin layer to tensile storage elastic modulus
of the second resin layer (the value of "first resin layer
tensile storage elastic modulus/"second resin layer tensile
storage elastic modulus") is from 5 to 500.

20 2. The hollow electronic device sealing resin sheet
according to claim 1, wherein the ratio of viscosity of the
first resin layer to viscosity of the second resin layer
(the value of "first resin layer viscosity"/"second resin
layer viscosity") is from 3 to 1000.

25 3. The hollow electronic device sealing resin sheet
according to claim 1 or 2, wherein the ratio of average
particle diameter of the filler in the first resin layer to
average particle diameter of the filler in the second resin
30 layer (the value of "average particle diameter of the

filler in the first resin layer"/"average particle diameter of the filler in the second resin layer") is from 0.01 to 0.5.

- 5 4. The hollow electronic device sealing resin sheet according to any one of claims 1 to 3, wherein the content of the filler in the first resin layer is 69% by volume or less, and the content of the filler in the second resin layer is more than 69% by volume.

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5. The hollow electronic device sealing resin sheet according to any one of claims 1 to 4, wherein the ratio of thickness of the first resin layer to thickness of the second resin layer (the value of "first resin layer
15 thickness"/"second resin layer thickness") is from 0.05 to 0.3.

6. The hollow electronic device sealing resin sheet according to any one of claims 1 to 5, wherein the
20 viscosity of the first resin layer is 10000 Pa·s or more.

7. A method for manufacturing a hollow electronic device package, comprising:

- a step of providing the hollow electronic device
25 sealing resin sheet recited in any one of claims 1 to 6;

a step of providing a substrate on which a hollow electronic device is to be mounted; and

a step of laminating the hollow electronic device sealing resin sheet on the substrate to bring the first

resin layer into contact with the hollow electronic device and the substrate.