

DESCRIPTION

TITLE OF THE INVENTION: SEALING THERMOSETTING-RESIN SHEET AND
HOLLOW-PACKAGE MANUFACTURING METHOD

TECHNICAL FIELD

[0001]

The present invention relates to a sealing thermosetting-resin sheet and a hollow package.

BACKGROUND ART

[0002]

In order to manufacture an electronic-device package, a process is typically adopted which includes: sealing one or more electronic devices fixed onto a substrate through, for example, bumps with a sealing resin; and dicing the sealed body, as needed, into packages which are each a package for any one of the electronic devices. As such a sealing resin, a sheet-form sealing resin may be used.

[0003]

In recent years, developments have been advanced about micro electronic devices called MEMS, such as SAW (surface acoustic wave) filters, CMOS (complementary metal oxide semiconductor) sensors, and acceleration sensors. In general, packages in which these electronic devices are sealed each have a hollow structure for transmitting a surface acoustic wave,

maintaining an optical system, or keeping the mobility of mobile members of the electronic devices. In many cases, this hollow structure is provided as a gap between a substrate of the package and the element(s) thereof. At the time of the sealing, it is necessary to attain the sealing while the hollow structure is maintained to ensure the operational reliability of the mobile member(s) and the connection reliability of the element(s). For example, Patent Document 1 describes a technique of using a gelatinous curable resin sheet to make a functional element into a hollow mold.

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0004]

Patent Document 1: JP-A-2006-19714

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0005]

About a hollow-package manufacturing method, a hollow package can be manufactured by, for example, a method including the step of pressuring a stacked body which includes a device mounted product having an adherend and an electronic device mounted on the adherend, and further includes a sealing thermosetting-resin sheet arranged over the device mounted

product to form a sealed body which includes the adherend, the electronic device mounted on the adherend, and the sealing thermosetting-resin sheet covering the electronic device, and the step of heating the sealed body to cure the sealing thermosetting-resin sheet. In such a manufacturing method, it is desired that a material constituting a resin sheet does not flow into a gap between an adherend and an electronic device.

[0006]

In light of this problem, the present invention has been made, and an object thereof is to provide a sealing thermosetting-resin sheet and a hollow-package manufacturing method with or by each of which a material constituting a sealing thermosetting-resin sheet does not flow easily into a gap between an adherend and an electronic device.

MEANS FOR SOLVING THE PROBLEM

[0007]

The present invention relates to a sealing thermosetting-resin sheet used to manufacture a hollow package. A cured body of the sealing thermosetting-resin sheet of the invention has a sea-island structure including a matrix part containing a first resin component as a main component, and a domain part containing a second resin component as a main component, and the matrix part is softer than the domain part.

[0008]

According to the sealing thermosetting-resin sheet of the present invention, a material constituting the sealing thermosetting-resin sheet does not flow easily into a gap between an adherend and an electronic device. Although the reason therefor is unclear, the reason is presumed as follows: by heating a sealed body obtained using the sealing thermosetting-resin sheet of the invention, the formation of the sea-island structure, which includes the domain part and the matrix part softer in the domain part, is advanced; thus, the material constituting the sealing thermosetting-resin sheet does not flow excessively.

[0009]

It is preferred that the cured body further contains a filler dispersed in the matrix part. This case makes it more difficult that the material constituting the sealing thermosetting-resin sheet flows into the gap between the adherend and the electronic device.

[0010]

It is preferred that the sealing thermosetting-resin sheet of the present invention contains a thermoplastic resin and a thermosetting resin. For the reason that the material constituting the sealing thermosetting-resin sheet does not flow easily into the gap between the adherend and the electronic device, it is preferred that the first resin component is the thermoplastic resin, and the second resin component is the

thermosetting resin.

[0011]

It is preferred that the domain part has a maximum particle diameter of 0.01 μm to 5 μm . This case makes it even more difficult that the material constituting the sealing thermosetting-resin sheet flows into the gap between the adherend and the electronic device. This is because a thixotropic effect can be given to the material which constitutes the sealing thermosetting-resin sheet positioned in the vicinity of the gap to regulate the flow of the material which constitutes the sealing thermosetting-resin sheet.

[0012]

It is preferred that the thermoplastic resin has an acid value of 1 mgKOH/g to 100 mgKOH/g. When the acid value is from 1 mgKOH/g to 100 mgKOH/g, the domain part can easily be formed with a maximum particle diameter of 0.01 μm to 5 μm .

[0013]

The present invention also relates to a hollow-package manufacturing method, including the step of pressuring a stacked body which includes a device mounted product including an adherend and an electronic device mounted on the adherend, and further includes the above-mentioned sealing thermosetting-resin sheet arranged over the device mounted product to form a sealed body which includes the adherend, the electronic device mounted on the adherend, and the sealing

thermosetting-resin sheet covering the electronic device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig. 1 is a schematic sectional view of a thermosetting-resin sheet.

Fig. 2 shows respective TEM observation images of cross sections of a cured body. Images in the lower stage of Fig. 2 are each a partially enlarged image obtained from an image in the upper stage.

Fig. 3 is an AFM phase image of a cross section of the cured body. This image is an image obtained by observing the cured body obtained by curing a thermosetting-resin sheet containing an epoxy resin, a phenolic resin, a thermoplastic resin and a curing accelerator but containing neither any filler nor any pigment to show a sea-island structure in the cured body vividly.

Fig. 4 is a TEM observation image of a cross section of the cured body. This image is an image obtained by observing the cured body obtained by curing the thermosetting-resin sheet containing the epoxy resin, the phenolic resin, the thermoplastic resin and the curing accelerator but containing neither any filler nor any pigment to show the sea-island structure vividly.

Fig. 5 is a sectional view which schematically

illustrates a stacked body in the state of being arranged between a lower heating plate and an upper heating plate.

Fig. 6 is a sectional view which schematically illustrates a situation that the stacked body is hot-pressed in a parallel-flat-plate manner.

Fig. 7 is a sectional view which schematically illustrates a situation that a separator is peeled off from a sealed body obtained by the hot-pressing.

Fig. 8 is a schematic sectional view of a cured body obtained by heating the sealed body.

Fig. 9 is a schematic sectional view of hollow packages obtained by individualizing the cured body into pieces.

Fig. 10 is a TEM observation image of a test piece of Example 1.

Fig. 11 is a TEM observation image of a test piece of Comparative Example 1.

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 only to these embodiments.

[0016]

[Embodiment 1]

Thermosetting-resin sheet 11:

A thermosetting-resin sheet 11 will be described.

[0017]

As illustrated in Fig. 1, the form of the thermosetting-resin sheet 11 is a sheet form. Typically, the thermosetting-resin sheet 11 is provided in the state of being arranged on a separator 12 such as a polyethylene terephthalate (PET) film. In order that the resin sheet 11 can easily be peeled off from the separator 12, the separator 12 is preferably a separator subjected to release treatment.

[0018]

The thermosetting-resin sheet 11 has thermosetting properties.

[0019]

In the thermosetting-resin sheet 11, a curing reaction thereof induces phase separation. In other words, in the thermosetting-resin sheet 11, a curing reaction thereof induces the formation of a sea-island structure.

[0020]

In Fig. 2 are shown observation images obtained by observing a cured body of the thermosetting-resin sheet 11 through a transmission electron microscope (TEM). It can be verified that the image arranged at the left side in the upper stage of Fig. 2 has, at the upper part of the image, a deep color region that is a matrix part and light color regions that are domain parts. It can also be verified that the image arranged

at the right side in the upper stage has, at the upper part of the image, a deep color region that is a matrix part and light color regions that are domain parts. The circular objects are a filler.

[0021]

As shown in Fig. 2, the cured body of the thermosetting-resin sheet 11 includes a sea-island structure including the matrix part (referred to also as the sea phase hereinafter) and the domain parts (referred to also as the island phase hereinafter) dispersed in the matrix part, and the filler dispersed in the matrix part. The matrix part is softer than the domain parts.

The cured body is obtained, for example, by heating the thermosetting-resin sheet 11 at 150°C for 1 hour to be cured.

[0022]

About the thermosetting-resin sheet 11, the material constituting the thermosetting-resin sheet 11 does not flow easily into a gap between an adherend and an electronic device. Although the reason therefor is unclear, the reason is presumed as follows: by heating a sealed body obtained using the thermosetting-resin sheet 11, the formation of the sea-island structure is advanced, this structure including the domain parts and the matrix part softer in the domain parts; thus, the material constituting the thermosetting-resin sheet 11 does not flow excessively.

[0023]

The softness of each of the matrix part and the domain parts can be known through, for example, an atomic force microscope (AFM).

[0024]

In Fig. 3, light color regions (regions that are not black) are regions small in phase lag. The regions small in phase lag are low in adsorbing performance to be hard regions. In the meantime, a deep color region is a region large in phase lag. The region large in phase lag is high in adsorbing performance to be a soft region.

[0025]

The matrix part contains a first resin component as a main component. The domain parts contain a second resin component as a main component.

[0026]

For the reason that the material constituting the thermosetting-resin sheet 11 does not flow easily into the gap between the adherend and the electronic device, it is preferred that the matrix part contains, as the main component thereof, a thermoplastic resin. In short, the first resin component is preferably the thermoplastic resin. It is preferred that the domain parts contain, as the main component thereof, a thermosetting resin. In short, the second resin component is preferably the thermosetting resin.

[0027]

When a comparison is made between an AFM observation result of the cured body and a transmission electron microscope (TEM) observation result thereof, it can be made clear that the matrix part contains, as the main component, the thermoplastic resin. It can be made clear that the domain parts contain, as the main component, the thermosetting resin.

[0028]

For reference, in Fig. 4 is shown a TEM observation image of the cured body used in Fig. 3. Its deep color region is a low-brightness region, and is a region containing a thermoplastic resin as a main component.

[0029]

In connection with the formation of the sea-island structure, the adjustment of, for example, the kind of functional groups of the thermoplastic resin and/or the content of the thermoplastic resin makes it possible to yield the thermosetting-resin sheet 11, in which formable is the sea-island structure including the domain parts and the matrix part softer than the domain parts.

[0030]

By increasing the content of the thermoplastic resin, the matrix part, which is softer than the domain parts, can easily be formed. For example, when the thermoplastic resin is blended to set the content of the thermoplastic resin to 10% by weight

or more of 100% by weight of the entire components other than the filler, the thermosetting-resin sheet 11 can be obtained, in which formable is the sea-island structure including the domain parts and the matrix part softer than the domain parts.

[0031]

For the reason that the sea-island structure can easily be formed, examples of the functional groups of the thermoplastic resin include carboxyl ($-\text{COOH}$), epoxy, hydroxyl, amino, and mercapto groups.

[0032]

The maximum particle diameter of the domain parts is preferably $0.01\text{ }\mu\text{m}$ or more, more preferably $0.03\text{ }\mu\text{m}$ or more, even more preferably $0.05\text{ }\mu\text{m}$ or more. When the maximum particle diameter is $0.01\text{ }\mu\text{m}$ or more, the raw materials can be regulated about the flow thereof when molded. In the meantime, the maximum particle diameter of the domain parts is preferably $5\text{ }\mu\text{m}$ or less, more preferably $4\text{ }\mu\text{m}$ or less, even more preferably $3\text{ }\mu\text{m}$ or less, even more preferably $1\text{ }\mu\text{m}$ or less, especially preferably $0.8\text{ }\mu\text{m}$ or less, most especially $0.5\text{ }\mu\text{m}$ or less. When the maximum particle diameter is $5\text{ }\mu\text{m}$ or less, a thixotropic effect can be given to the material constituting the thermosetting-resin sheet 11, the material being positioned in the vicinity of the gap, to regulate the flow of the material which constitutes the thermosetting-resin sheet 11.

[0033]

The maximum particle diameter of the domain parts is controllable by the amount of the functional groups of the thermoplastic resin. For example, by blending a thermoplastic resin large in functional group amount, the maximum particle diameter of the domain parts can be made small. The maximum particle diameter of the domain parts is also affected by the compatibility between the thermosetting resin and the thermoplastic resin. However, the maximum particle diameter of the domain parts is more largely affected by the amount of the functional groups of the thermoplastic resin.

[0034]

The maximum particle diameter of each of the domain parts is the following in an observation image obtained by observing the domain part through a transmission electron microscope (TEM): the maximum distance out of individual distances between any two points on the contour of the domain part. The maximum particle diameter of the domain parts can be calculated by averaging respective measured values obtained by observing 100 regions out of the domain parts. When plural ones out of the domain parts are gathered or aggregated with one another, any one of the gathered or aggregated regions that each have a continuous contour is handled as a single domain part. Specifically, the maximum particle diameter is measurable by a method described in the EXAMPLES.

[0035]

The temperature Tg (glass transition temperature) of the cured body is preferably 100°C or higher, more preferably 120°C or higher. The temperature Tg of the cured body is preferably 200°C or lower, more preferably 170°C or lower. When the temperature Tg is in the range, the cured body can gain good reliability in various reliability tests such as a temperature cycle test and a reflow test.

The temperature Tg is measurable by a method described in the EXAMPLES.

[0036]

The temperature Tg of the cured body is controllable by the crosslink density thereof. The temperature Tg is heightened, for example, by using a thermosetting resin having, in the molecule thereof, many functional groups.

[0037]

At the temperature Tg or lower, the coefficient of linear expansion (CTE1) of the cured body is preferably 20 ppm/K or less, more preferably 17 ppm/K or less. When the coefficient is 20 ppm/K or less, the cured body can be decreased in being warped. In the meantime, the lower limit of the coefficient CTE1 of the cured body is not particularly limited. For example, the coefficient CTE1 of the cured body is 5 ppm/K or more or 8 ppm/K or more.

The linear expansion coefficient is measurable by a method described in the EXAMPLES.

[0038]

The linear expansion coefficient of the cured body is controllable by the content of an inorganic filler therein or others. For example, the linear expansion coefficient can be made small by increasing the content of the inorganic filler.

[0039]

The tensile storage elastic modulus of the cured body is preferably 1 GPa or more, more preferably 3 GPa or more at 25°C. When the elastic modulus is 1 GPa or more, the cured body can be restrained from suffering from a warp generated when formed and subsequently returned to ambient temperature. The tensile storage elastic modulus of the cured body is preferably 15 GPa or less, more preferably 10 GPa or less at 25°C. When the elastic modulus is 15 GPa or less, a stress in the cured resin can be made small, the stress being generated by a matter that the cured body is returned to ambient temperature to be deformed. Thus, it is possible to restrain the adherend from receiving the stress concentration to be peeled or cracked.

The tensile storage elastic modulus is measurable by a method described in the EXAMPLES.

[0040]

The tensile storage elastic modulus of the cured body is controllable mainly by the content of the inorganic filler. For example, the tensile storage elastic modulus can be heightened by increasing the content of the inorganic filler.

[0041]

About the thermosetting-resin sheet 11, the minimum melt viscosity at 60°C to 130°C is preferably 2000 Pa·s or more, more preferably 5000 Pa·s or more. When the minimum melt viscosity is 2000 Pa·s or more, the material constituting the thermosetting-resin sheet 11 does not flow easily into the hollow region.

In the meantime, the minimum melt viscosity of the thermosetting-resin sheet 11 at 60°C to 130°C is preferably 20000 Pa·s or lower, more preferably 15000 Pa·s or lower. When the minimum melt viscosity is 20000 Pa·s or lower, an electronic device can easily be embedded in the thermosetting-resin sheet 11 so that the generation of voids can be decreased.

The minimum melt viscosity is measurable by a method described in the EXAMPLES.

[0042]

It is preferred that the thermosetting-resin sheet 11 contains the thermosetting resin and the thermoplastic resin.

[0043]

It is preferred in the thermosetting-resin sheet 11 that the thermosetting resin and the thermoplastic resin are compatible with each other. The compatibility does not cause any segregation of the thermosetting resin or any segregation of the thermoplastic resin, so that the cured body can be decreased in being warped.

The matter that the thermosetting resin and the thermoplastic resin are compatible with each other means that in an observation image of the sheet 11 through a transmission electron microscope (TEM), no structure of phase separation between the thermosetting resin and the thermoplastic resin is observed.

[0044]

The thermosetting resin is not particularly limited, and is preferably an epoxy resin, or a phenolic resin.

[0045]

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.

[0046]

In order to ensure the reactivity of the epoxy resin, the epoxy resin is preferably an epoxy resin having an epoxy equivalent of 150 to 250 and a softening point or melting point of 50 to 130°C to be in a solid state at ambient temperature. Out of such epoxy resins, more preferred are triphenylmethane

type epoxy resin, cresol novolak type epoxy resin and biphenyl type epoxy resin from the viewpoint of reliability. Bisphenol F type epoxy resin is preferred since the resin can give flexibility to the thermosetting-resin sheet 11.

[0047]

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

[0048]

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

[0049]

About the blend ratio between the epoxy resin and the phenolic resin, from the viewpoint of the curing reactivity, the two resins are blended with each other to set the total equivalent of hydroxyl groups in the phenolic resin into a range

preferably from 0.7 to 1.5 equivalents, more preferably from 0.9 to 1.2 equivalents per equivalent of epoxy groups in the epoxy resin.

[0050]

The thermosetting resin content in the sheet 11 is preferably 70% by weight or more, more preferably 75% by weight or more, even more preferably 80% by weight or more of 100% by weight of the entire components other than the filler. When the content is 70% by weight or more, the coefficient CTE1 of the cured body can be made small. In the meantime, the thermosetting resin content is preferably 95% by weight or less, more preferably 92% by weight or less, even more preferably 90% by weight or less, in particular preferably 88% by weight or less.

[0051]

The thermosetting-resin sheet 11 preferably contains a curing accelerator.

[0052]

The curing accelerator is not particularly limited as long as it promotes curing of the epoxy resin and the phenolic resin. Examples thereof include imidazole-based curing accelerators such as 2-methylimidazole (trade name; 2MZ), 2-undecylimidazole (trade name; C11-Z), 2-heptadecylimidazole (trade name; C17Z), 1,2-dimethylimidazole (trade name; 1.2DMZ), 2-ethyl-4-methylimidazole (trade name; 2E4MZ),

2-phenylimidazole (trade name; 2PZ),
 2-phenyl-4-methylimidazole (trade name; 2P4MZ),
 1-benzyl-2-methylimidazole (trade name; 1B2MZ),
 1-benzyl-2-phenylimidazole (trade name; 1B2PZ),
 1-cyanoethyl-2-methylimidazole (trade name; 2MZ-CN),
 1-cyanoethyl-2-undecylimidazole (trade name; C11Z-CN),
 1-cyanoethyl-2-phenylimidazolium trimellitate (trade name;
 2PZCNS-PW),
 2,4-diamino-6-[2'-methylimidazolyl-(1')]-ethyl-s-triazine
 (trade name; 2MZ-A),
 2,4-diamino-6-[2'-undecylimidazolyl-(1')]-ethyl-s-triazine
 (trade name; C11Z-A),
 2,4-diamino-6-[2'-ethyl-4'-methylimidazolyl-(1')]-ethyl-s-t
 riazine (trade name; 2E4MZ-A),
 2,4-diamino-6-[2'-metthylimidazolyl-(1')]-ethyl-s-triazine
 isocyanuric acid adduct (trade name; 2MA-OK),
 2-phenyl-4,5-dihydroxymethylimidazole (trade name; 2PHZ-PW),
 and 2-phenyl-4-methyl-5-hydroxymethylimidazole (trade name;
 2P4MZ-PW) (all of these compounds are manufactured by Shikoku
 Chemicals Corporation).

[0053]

Out of such curing accelerators, any imidazole type
 curing accelerator is preferred since the promoter is good in
 curing promoting power to give a cured body high in glass
 transition temperature Tg. More preferred are

2-phenyl-4,5-dihydroxymethylimidazole and
2,4-diamino-6-[2'-ethyl-methylimidazolyl-(1')]-ethyl-s-tria
zine, and even more preferred is
2-phenyl-4,5-dihydroxymethylimidazole.

[0054]

The content of the curing accelerator in the
thermosetting composition is preferably 0.2 part or more, more
preferably 0.5 part or more, even more preferably 0.8 part or
more by weight for 100 parts by weight of the total of the epoxy
resin and the phenolic resin. The content of the curing
accelerator is preferably 5 parts or less, more preferably 2
parts or less by weight for 100 parts by weight of the total
of the epoxy resin and the phenolic resin.

[0055]

It is preferred that the thermosetting-resin sheet 11
contains the thermoplastic resin. The thermoplastic resin is
preferably a resin that can function as an elastomer.

[0056]

Examples of the thermoplastic resin include acrylic
elastomers, urethane elastomers, silicone elastomers, and
polyester elastomers. Out of these examples, acrylic
elastomers are preferred since the resins easily gain
flexibility and are good in dispersibility in an epoxy resin.

[0057]

The acrylic elastomer 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.

[0058]

A different monomer which constitutes the above-mentioned polymer 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. It is particularly preferred that the thermosetting composition 11 contains at least one out of carboxyl-group-containing monomers, glycidyl-group-containing (epoxy-group-containing) monomers, and hydroxyl-group-containing monomers since these monomers can each react with any epoxy resin to make the thermosetting-resin sheet 11 high in viscosity.

[0059]

The thermoplastic resin preferably has a functional group. The functional group is preferably a carboxyl group, an epoxy group, a hydroxyl group, an amino group, or a mercapto group, and is more preferably a carboxyl group since the functional group makes it possible to form the sea-island structure easily.

[0060]

The acid value of the thermoplastic resin is preferably 1 mgKOH/g or more, more preferably 3 mgKOH/g or more, even more preferably 10 mgKOH/g or more. When the acid value is 1 mgKOH/g or more, the domain parts can be made small in size so that the flow of the material constituting the thermosetting resin 11 can be regulated. In the meantime, the acid value of the thermoplastic resin is preferably 100 mgKOH/g or less, more

preferably 60 mgKOH/g or less, even more preferably 50 mgKOH/g or less, in particular preferably 40 mgKOH/g or less. When the acid value is 100 mgKOH/g or less, the storage stability of the thermosetting-resin sheet 11 that is affected by the acid value can be kept relatively good.

The acid value is measurable by a neutralization titration method prescribed in JIS K 0070-1992.

[0061]

The weight-average molecular weight of the thermoplastic resin is preferably 500,000 or more, more preferably 800,000 or more. When the weight-average molecular weight is 500,000 or more, the thermoplastic resin is not excessively low in viscosity to be easily handled when blended with other materials. In the meantime, the weight-average molecular weight of the thermoplastic resin is preferably 2,000,000 or less, more preferably 1,500,000 or less. When the weight-average molecular weight is 2,000,000 or less, the thermoplastic resin is not excessively high in viscosity to be easily handled when blended with other materials.

The weight-average molecular weight is a value obtained by measuring the resin by GPC (gel permeation chromatography) and then converting the resultant value into a value in terms of the molecular weight of polystyrene.

[0062]

The temperature T_g of the thermoplastic resin is

preferably -70°C or higher, more preferably -50°C or higher. When the temperature T_g is -70°C or higher, the polymer is easily designed and further the elastic modulus is not excessively low at the molding temperature so that the thermosetting-resin sheet 11 is easily controlled in embedding performance at the time of the molding. In the meantime, the temperature T_g of the thermoplastic resin is preferably 20°C or lower, more preferably 0°C or lower. When the temperature is 20°C or lower, the elastic modulus is not excessively high at the molding temperature so that the thermosetting-resin sheet 11 is easily controlled in embedding performance at the time of the molding.

[0063]

In the present specification, the glass transition temperature of the thermoplastic resin is a theoretical value obtained in accordance with the Fox equation.

A different method for obtaining the glass transition temperature of the thermoplastic resin is a method of obtaining the glass transition temperature by use of a temperature at a time for a maximum thermal absorption peak of the polymer that is measured by means of a differential scanning thermometer (DSC). Specifically, a differential scanning thermometer, "Q-2000", manufactured by a company, TA Instruments is used to heat, for 10 minutes, a sample to be measured at a temperature about 50°C higher than a forecasted glass transition temperature (forecasted temperature) of the sample, and then the sample is

cooled to a temperature about 50°C lower than the forecasted temperature to pre-treat the sample. Thereafter, the temperature of the sample is raised at a temperature-raising rate of 5°C/minute in a nitrogen atmosphere to measure the thermal absorption starting temperature. This temperature is defined as the glass transition temperature of the sample.

[0064]

The thermoplastic resin content in the sheet 11 is preferably 5% by weight or more, more preferably 10% by weight or more, even more preferably 11% by weight or more, even more preferably 12% by weight or more, in particular preferably 13% by weight or more of 100% by weight of the entire components other than the filler. When the content is 5% by weight or more, the sea-island structure may be formed. When the content is 10% by weight or more, the sea-island structure can easily be formed. In the meantime, the thermoplastic resin content is preferably 30% by weight or less, more preferably 20% by weight or less. When the content is 30% by weight or less, the thermosetting-resin sheet 11 is not excessively high in storage elastic modulus to attain consistency between embedding performance and flow regulation.

[0065]

It is preferred that the thermosetting-resin sheet 11 contains the filler. The blend of the filler into the sheet can make the thermal expansion coefficient α thereof small.

The filler is preferably, for example, an inorganic filler.

[0066]

Examples of the inorganic filler include quartz glass, talc, silica species (such as fused silica and crystalline silica), alumina (aluminum oxide), boron nitride, aluminum nitride, and silicon carbide. Out of these examples, silica species are preferred since the species can satisfactorily decrease the thermal expansion coefficient of the sealing sheet. Out of the silica species, fused silica is preferred since this species is excellent in fluidity. Spherical fused silica is more preferred. A thermoconductive filler is also preferred since the filler is high in thermoconductivity. Alumina, boron nitride and aluminum nitride are more preferred. The inorganic filler is preferably an electrically insulating filler.

[0067]

The average particle diameter of the filler is preferably 0.5 μm or more, more preferably 1 μm or more. When the average particle diameter is 0.5 μm or more, the thermosetting-resin sheet 11 easily gains flexibility and softness. The average particle diameter of the filler is preferably 30 μm or less, more preferably 10 μm or less. When the average particle diameter is 30 μm or less, the filler is easily filled at a high degree into the sheet.

The average particle diameter can be derived, for example, by using a sample extracted at will from a population of the

particles, and measuring the sample using a laser-diffraction-scattering type particle size distribution measuring instrument.

[0068]

The particle size distribution of the filler preferably has at least a peak A and a peak B. Specifically, it is preferred that the particle size distribution has a peak A in a particle diameter range of 0.01 μm to 10 μm and a peak B in the particle diameter range of 1 μm to 100 μm . This case makes it possible to fill particles of the filler that form the peak A, in a high degree, into spaces between particles of the filler that form the peak B.

[0069]

The particle size distribution more preferably has the peak A in a particle diameter range of 0.1 μm or more. The particle size distribution more preferably has the peak A in a particle diameter range of 1 μm or less.

[0070]

The particle size distribution more preferably has the peak B in a particle diameter range of 3 μm or more. The particle size distribution more preferably has the peak B in a particle diameter range of 10 μm or less.

[0071]

The particle size distribution of the filler may have a peak other than the peaks A and B.

[0072]

The particle size distribution of the filler is measurable by the following method:

[0073]

Method for measuring the particle size distribution of the filler:

The thermosetting-resin sheet 11 is put into a crucible, and the crucible is intensely heated to incinerate the thermosetting-resin sheet 11. The resultant ash content is dispersed into pure water, and the resultant is subjected to ultrasonic treatment for 10 minutes. Using a laser-diffraction-scattering type particle size distribution measuring instrument (using a wet method; "LS 13 320", manufactured by Beckman Coulter, Inc.), the (volume-reference) particle size distribution thereof is then obtained.

[0074]

The inorganic filler may be treated (pre-treated) with a silane coupling agent. This case makes it possible that the inorganic filler is improved in wettability with a resin to be heightened in dispersibility.

[0075]

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

[0076]

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.

[0077]

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 phenol resin.

[0078]

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.

[0079]

A method of treating the inorganic filler with the silane coupling agent is not especially limited, and examples thereof include a wet method of mixing the inorganic filler and the

silane coupling agent in a solvent and a dry method of treating the inorganic filler with the silane coupling agent in a gas phase.

[0080]

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 inorganic filler.

[0081]

The filler content in the thermosetting-resin sheet 11 is preferably 60% by volume or more, more preferably 70% by volume or more. When the content is 60% by volume or more, the cured body can be made small in CTE1. In the meantime, the filler content is preferably 90% by volume or less, more preferably 80% by volume or less. When the content is 90% by volume or less, the raw materials can easily be molded into a sheet.

[0082]

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 thermosetting-resin sheet 11 is preferably 75% by weight or more, more preferably 80% by weight or more. In the meantime, the content of silica in the thermosetting-resin sheet 11 is preferably 95% by weight or less, more preferably 90% by weight or less.

[0083]

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 thermosetting-resin sheet 11 is preferably 85% by weight or more, more preferably 90% by weight or more. In the meantime, the content of alumina in the thermosetting-resin sheet 11 is preferably 97% by weight or less, more preferably 95% by weight or less.

[0084]

The thermosetting-resin sheet 11 may appropriately contain, besides the above-mentioned components, blending agents used ordinarily to produce a sealing resin, for example, a pigment.

[0085]

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

[0086]

The method for producing the thermosetting-resin sheet

11 is not particularly limited. The thermosetting-resin sheet 11 can be obtained, for example, by dissolving or dispersing the resin(s) and others for forming the thermosetting-resin sheet 11 in an appropriate solvent to prepare a vanish, applying this vanish onto the separator 12 to have a predetermined thickness to form a coating film, and then drying the coating film under predetermined conditions. The method for the application is not particularly limited. Examples thereof include roll coating, screen coating, and gravure coating. About conditions for the drying, for example, the drying temperature ranges from 70 to 160°C, and the drying period ranges from 1 to 30 minutes. The production method is also preferably a method of applying the above-mentioned vanish onto a separator different from the separator 12 to form a coating film, drying the coating film to form the thermosetting-resin sheet 11, and then bonding the thermosetting-resin sheet 11 onto the separator 12. When the thermosetting-resin sheet 11 contains, in particular, a thermoplastic resin, an epoxy resin and a phenolic resin, all of these resins are dissolved in a solvent and further the solution is applied and dried. This method makes it possible to improve the thermosetting-resin sheet 11 in viscosity to restrain the resin components from invading the hollow region. Examples of the solvent include methyl ethyl ketone, ethyl acetate, and toluene.

[0087]

It is also preferred to produce the thermosetting-resin sheet 11 by kneading-extrusion. This case makes it possible to mold the raw materials therefor easily into a sheet form to yield the thermosetting-resin sheet 11 with a small number of voids and an even thickness. The production method using the kneading-extrusion is preferably a method of kneading the above-mentioned individual components (for example, the thermosetting resin, curing accelerator, thermoplastic resin and filler), and then working the resultant kneaded body plastically into a sheet form. This method makes it possible to attain high-degree filling of the filler, and design the sheet to have a low thermal expansion coefficient.

[0088]

Specifically, a known kneader, such as a mixing roll, a pressurizing kneader or an extruder, is used to melt and knead the thermosetting resin, the curing accelerator, the thermoplastic resin, the filler, and others to prepare a kneaded product. The resultant kneaded product is plastically worked into a sheet form. About the kneading conditions, the temperature is preferably 140°C or lower, more preferably 130°C or lower. Moreover, 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 performed preferably under a reduced

pressure (or in a reduced-pressure atmosphere). The pressure under the reduced pressure is, for example, from 1×10^{-4} to 0.1 kg/cm².

[0089]

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.

[0090]

The thickness of the thermosetting-resin sheet 11 is not particularly limited, and is preferably 100 μm or more, more preferably 150 μm or more and is also preferably 2000 μm or less, more preferably 1000 μm or less. When the thickness is in the range, the sheet 11 can satisfactorily seal an electronic device.

[0091]

The thermosetting-resin sheet 11 is used to produce a hollow package. Examples of the hollow package include sensor packages, MEMS (micro electro mechanical system) packages, and SAW (surface acoustic wave) filters.

[0092]

The hollow package has, for example, a substrate, an electric device mounted on the substrate, and a cured resin covering the electronic device. A hollow region is provided between the electronic device and the substrate. Examples of the substrate include a printed wiring board, an LTCC (low temperature co-fired ceramic) substrate (hereinafter referred to also as a low temperature co-fired ceramic substrate), a ceramic substrate, a silicon substrate, and a metallic substrate. Examples of the electronic device include sensors, MEMS, and SAW chips. Out of these examples, a pressure sensor, a vibration sensor, or SAW chips are preferably usable. SAW chips are in particular preferably usable. The cured resin is produced by curing the thermosetting-resin sheet 11.

[0093]

A typical example of a method for manufacturing a hollow package using the thermosetting-resin sheet 11 is a method of embedding an electronic device in the thermosetting-resin sheet 11.

[0094]

The thermosetting-resin sheet 11 can function as a

sealing resin for protecting the electronic device and elements accompanying the device from the external environment.

[0095]

Method for Manufacturing Hollow package:

As illustrated in Fig. 5, a stacked body 31 is arranged between a lower heating plate 41 and an upper heating plate 42. The stacked body 31 has a device mounted product 2, a thermosetting-resin sheet 11 arranged on the device mounted product 2, and a separator 12 arranged on the thermosetting-resin sheet 11.

[0096]

The device mounted product 2 has a substrate 22, and SAW chips 23 mounted on the substrate 22. The SAW chips 23 can be obtained by dicing a piezoelectric crystal in which predetermined interdigitated array electrodes are formed into individual pieces by a known method. The SAW chips 23 can be arranged on the substrate 22, using a known machine such as a flip chip bonder or a die bonder. The SAW chips 23 are electrically connected to the substrate 22 through bump electrodes 24 such as bumps. A hollow region 25 is kept between each of the SAW chips 23 and the substrate 22 not to hinder the transmission of surface acoustic waves on the front surface of the SAW filter. The distance between the SAW chip 23 and the substrate 22 (referred to also as the width of the hollow region 25B hereinafter) may be appropriately set, and is generally from

about 10 μm to 100 μm . In other words, the device mounted product 2 has the substrate 22, the bump electrodes 24 arranged on the substrate 22, and the SAW chips 23 each arranged on some of the bump electrodes 24.

[0097]

As illustrated in Fig. 6, the lower heating plate 41 and the upper heating plate 42 are used to hot-press the stacked body 31 in a parallel-flat-plate manner to form a sealed body 32.

[0098]

The hot-pressing temperature is preferably 40°C or higher, more preferably 50°C or higher, even more preferably 60°C or higher. When the temperature is 40°C or higher, the stacked body can be sufficiently sealed. The hot-pressing temperature is also preferably 150°C or lower, more preferably 90°C or lower, even more preferably 80°C or lower. When the temperature is 150°C or lower, the curing reaction does not advance excessively before the stacked body is shaped. Thus, the stacked body can be sufficiently sealed.

[0099]

The pressure at which the stacked body 31 is hot-pressed is preferably 0.1 MPa or more, more preferably 0.5 MPa or more, even more preferably 1 MPa or more. This pressure is also preferably 10 MPa or less, more preferably 8 MPa or less. When the pressure is 10 MPa or less, a large damage is not given to

the SAW chips 23.

[0100]

The hot-pressing period is preferably 0.3 minute or longer, more preferably 0.5 minute or longer. The hot-pressing period is also preferably 10 minutes or shorter, more preferably 5 minutes or shorter.

[0101]

The hot-pressing is performed preferably in a reduced pressure atmosphere. The hot-pressing in the reduced pressure atmosphere makes it possible to decrease voids in the resultant sealed body and embed irregularities of the members therein satisfactorily. About conditions for the pressure decrease, the pressure is, for example, from 0.01 kPa to 5 kPa, preferably from 0.1 Pa to 100 Pa.

[0102]

The sealed body 32 yielded by hot-pressing the stacked body 31 has the substrate 22, the SAW chips 23 mounted on the substrate 22, and the thermosetting-resin sheet 11 covering the SAW chips 23. The separator 12 is arranged on the sealed body 32.

[0103]

As illustrated in Fig. 7, the separator 12 is peeled off from the sealed body 32.

[0104]

By heating the sealed body 32, the thermosetting-resin

sheet 11 is cured to form a cured body 33.

[0105]

The heating temperature is preferably 100°C or higher, more preferably 120°C or higher. The heating temperature is also 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 heating period is also preferably 180 minutes or shorter, more preferably 120 minutes or shorter. The sealed body 32 is heated preferably in an increased pressure atmosphere. The pressure is preferably 0.1 MPa or more, more preferably 0.5 MPa or more. The pressure is also preferably 10 MPa or less, more preferably 5 MPa or less. It is also preferred to heat the sealed body 32 in the atmospheric pressure.

[0106]

As illustrated in Fig. 8, the cured body 33 has the substrate 22, the SAW chips 23 mounted on the substrate 22, and a cured resin 26 covering the SAW chips 23.

[0107]

As illustrated in Fig. 9, the cured body 33 is individualized (diced) to yield hollow packages 34. This process makes it possible to yield the hollow packages 34 that are each for any one of the SAW chips 23. Each of the hollow packages 34 has the substrate 22, one of the SAW chips 23 that is mounted on the substrate 22, and the cured resin 26 covering

the SAW chip 23.

[0108]

It is allowable to form bumps on the hollow package 34, and mount the resultant onto another substrate (not illustrated). For mounting the hollow package 34 onto the substrate, a known device such as a flip chip bonder or a die bonder is usable.

[0109]

Modified Example 1:

In Embodiment 1, the thermosetting-resin sheet 11 has a mono-layered structure. However, in Modified Example 1, a thermosetting-resin sheet 11 has a multi-layered structure in which thermosetting resin layers are laminated onto each other. About the thermosetting-resin sheet 11 of Modified Example 1, as far as a cured layer yielded by curing a thermosetting resin layer contacting an electronic device includes a sea-island structure including a domain part and a matrix part softer than the domain part and further contains the filler dispersed in the matrix part, the other thermosetting resin layer(s) is/are not particularly restricted.

[0110]

Modified Example 2:

In Example 1, the stacked body 31 is pressured in a parallel-flat-plate manner. However, in Modified Example 2, a laminator is used to pressure the stacked body 31.

[0111]

Modified Example 3:

In Example 1, the stacked body 31 is hot-pressed. However, in Modified Example 3, a stacked body, which has the device mounted product 2 and the thermosetting-resin sheet 11 arranged on the device mounted product 2, is hot-pressed (not illustrated).

EXAMPLES

[0112]

Hereinafter, preferred examples of this invention will be illustratively described in detail. However, about materials, blend amounts and others that are described in the examples, the scope of this invention is not limited only thereto unless the specification includes any restrictive description thereabout.

[0113]

Components used in Example 1, Examples 7 to 9 and Comparative Example 1 are as follows:

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: LVR8210DL, manufactured by Gunee Chemical Industry Co., Ltd. (novolak type phenolic resin; hydroxyl equivalent: 104 g/eq., and softening point: 60°C)

Thermoplastic resin 1: ME-2000M, manufactured by Negami Chemical Industrial Co., Ltd. (acrylic ester copolymer containing carboxyl groups; weight-average molecular weight: about 600,000, Tg: -35°C, and acid value: 20 mgKOH/g)

Thermoplastic resin 2: HME-2006, manufactured by Negami Chemical Industrial Co., Ltd. (acrylic ester copolymer containing carboxyl groups; weight-average molecular weight: about 840,000, Tg: -47°C, and acid value: 32 mgKOH/g)

Thermoplastic resin 3: SG-280, manufactured by Nagase Chemtex Corporation (acrylic ester copolymer containing carboxyl groups; weight-average molecular weight: about 900,000, Tg: -29°C, and acid value: 30 mgKOH/g)

Thermoplastic resin 4: NSC-010, manufactured by Negami Chemical Industrial Co., Ltd. (acrylic ester copolymer containing carboxyl groups; weight-average molecular weight: about 930,000, Tg: -13°C, and acid value: 5 mgKOH/g)

Carbon black: #20, manufactured by Mitsubishi Chemical Corporation

Filler 1: FB-5SDC, manufactured by Denka Co., Ltd. (spherical silica; average particle diameter: 5 μm)

Filler 2: SO-25R, manufactured by Admatechs Company Limited (spherical silica; average particle diameter: 0.5 μm)

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

[0114]

[Thermosetting-resin sheet Production]

In each of the examples, in accordance with blend proportions shown in Table 1, individual components were dissolved and dispersed in methyl ethyl ketone as a solvent to prepare a vanish having a concentration of 90% by weight. The vanish was applied onto a release-treated film which was a polyethylene terephthalate film subjected to silicone release treatment and having a thickness of 38 μm . Thereafter, the resultant was dried at 110°C for 5 minutes. In this way, each sheet having a thickness of 65 μm was yielded. Four of the resultant sheets were laminated onto each other to yield a thermosetting-resin sheet having a thickness of 260 μm .

[0115]

[Cured Body Production]

A heating oven was used to heat and cure the thermosetting-resin sheet at 150°C for 1 hour. In this way, a cured body was yielded.

[0116]

[Test Piece Production]

In the same way as used to produce the thermosetting-resin sheet except that the fillers 1 and 2 and the carbon black were not blended, a testing resin sheet was produced. A heating oven was used to heat and cure the testing resin sheet at 150°C for 1 hour. In this way, a test piece was yielded.

The reason why the test piece was produced is to observe its sea-island structure. Even when the cured body is observed, its sea-island structure can be checked; however, the observation of the test piece makes it possible to check its sea-island structure easily.

[0117]

[Evaluations]

In each of the examples, evaluations described below were made about the thermosetting-resin sheet, the cured body and the test piece. The results are shown in Table 1.

[0118]

Phase Separation in Thermosetting-resin Sheet:

A cut surface of the thermosetting-resin sheet was observed through a TEM to check whether or not phase separation was caused therein.

[0119]

Minimum Melt Viscosity of Thermosetting-resin Sheet:

About the thermosetting-resin sheet, a dynamic viscoelasticity measuring instrument (ARES, manufactured by TA Instruments) was used to measure the viscosity thereof under the following measuring conditions: a gap of 1 mm, a parallel plate diameter of 25 mm, a measuring frequency of 0.1 Hz, a strain of 0.1%, a measuring temperature range of 60°C to 130°C, and a heating rate of 10°C/minute. The minimum value of the resultant viscosity values was defined as the minimum

viscosity.

[0120]

Tensile Storage Elastic Modulus and Tg of Cured Body:

From the cured body, a rectangular test piece was cut out with a utility knife, this piece having a length of 40 mm, a width of 10 mm and a thickness of 200 μm . A solid viscoelasticity measuring instrument (RSA III, manufactured by Rheometric Scientific) was used to measure the storage elastic modulus and the loss modulus of the test piece at temperatures from -50°C to 300°C . Conditions for the measurement were a frequency of 1 Hz and a heating rate of $10^{\circ}\text{C}/\text{minute}$. Furthermore, the value of the $\tan\delta$ (the ratio of G'' (loss modulus)/ G' (storage elastic modulus) of the test piece was calculated to gain the temperature Tg thereof.

[0121]

CTE1 of Cured Body:

From the cured body, a measuring specimen was cut out with a utility knife, this specimen having a length of 15 mm, a width of 5 mm and a thickness of 200 μm . The measuring specimen was set to a film tension measuring tool of a thermomechanical analyzer (TMA 8310, manufactured by Rigaku Corporation). Thereafter, the specimen was allowed to stand still under conditions of a tension load of 2 g and a heating rate of $5^{\circ}\text{C}/\text{minute}$ in a temperature range of -50°C to 300°C . The coefficient CTE1 of the specimen was calculated from the

expansion coefficient thereof at temperatures of 50°C to 70°C.

[0122]

Phase Separation in Test Piece:

The test piece was observed through a TEM to check whether or not phase separation was caused therein (see Figs. 10 and 11).

[0123]

AFM Observation of Test Piece:

A cut surface of the test piece was observed through an AFM to check each of its sea phase and an island phase as to which of the thermosetting resin and the thermoplastic resin was a main component.

[0124]

Maximum Diameter of Particles of Island Phase:

A cut surface of the cured body was observed through the TEM. From the resultant observation image, the maximum diameter of particles of the island phase was gained.

[0125]

Amount of Resin Invasion into Hollow Region:

SAW chips having a specification described below, including aluminum interdigitated array electrodes, were mounted onto a ceramic substrate under bonding conditions described below to manufacture a SAW chip mounted substrate having the ceramic substrate and the SAW chips mounted on the ceramic substrate. The gap width between the SAW chips and the

ceramic substrate was 20 μm .

[0126]

<SAW Chips>

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

Bump material: Au (height: 20 μm)

The number of the bumps: six

The number of the chips: 100 (10 $\times$ 10)

[0127]

<Bonding Conditions>

Machine manufactured by Panasonic Corp.

Bonding conditions: 3 N at 200°C for 1 sec.; ultrasonic
power: 2 W

[0128]

The thermosetting-resin sheet was arranged on the SAW chip mounted substrate to yield a stacked body. Under heating and pressurizing conditions described below, the stacked body was vacuum-pressed in a parallel-flat-plate manner to yield a sealed body.

[0129]

<Vacuum-Pressing Conditions>

Temperature: 60°C

Pressuring force: 4 MPa

Vacuum degree: 1.6 kPa

Pressing period: 1 minute

[0130]

The vacuum-press machine was released into the atmospheric pressure, and then the sealed body was heated at 150°C for 1 hour in a hot-air dryer to yield a cured body. The resultant cured body was cleaved between the substrate and the sealing resin to measure the amount of invasion of the resin into the hollow region between the SAW chips and the ceramic substrate through a microscope having a trade name "DIGITAL MICROSCOPE" (magnifying power of 200) and manufactured by KEYENCE CORPORATION. About the resin invasion amount, the maximum traveling distance of the resin invading the hollow region from the SAW chip end was measured, and this distance was defined as the resin invasion amount of the thermosetting-resin sheet. When the resin invasion amount was 20 μm or less, the sheet was evaluated to be O; or when the amount was more than 20 μm , the sheet was evaluated to be x.

[0131]

[Table 1]

	Example 1	Comparative Example 1	Example 7	Example 8	Example 9
Blend proportions (part(s) by weight)	Epoxy resin (YSLV-80XY)	8.4	7.9	7.9	7.9
	Phenolic resin (LVR8210DL)	4.6	4.3	4.3	4.3
	Thermoplastic resin 1 (ME-2000)	0.5	-	-	-
	Thermoplastic resin 2 (HME-2006)	-	2.3	-	-
	Thermoplastic resin 3 (SG-280)	-	-	2.3	-
	Thermoplastic resin 4 (NSC-010)	-	-	-	2.3
	Carbon black (#20)	0.3	0.3	0.3	0.3
	Filler 1 (FB-5SDO)	67.2	67.2	67.2	67.2
	Filler 2 (SO-25R)	17.9	17.9	17.9	17.9
	Curing accelerator (2PHZ-PW)	0.1	0.1	0.1	0.1
Total					
Thermoplastic resin content (% by weight) in entire components (100% by weight) other than fillers		100.0	100.0	100.0	100.0
Filler content (% by weight) in thermosetting-resin sheet (100% by weight)		15.4	15.4	15.4	15.4
Filler content (% by volume) in thermosetting-resin sheet		85.1	85.1	85.1	85.1
Thermosetting-resin sheet thickness (μm)		75.1	75.1	75.1	75.1
Thermosetting-resin sheet thickness (μm)		260	260	260	260
Evaluations	Phase separation in thermosetting resin sheet (B-stage)	Not caused	Not caused	Not caused	Not caused
	Minimum melt viscosity (Pa·s) of thermosetting-resin sheet	8000	6000	12000	14500
	Tensile storage elastic modulus (GPa) of cured body	5	4	5	5.5

Sea-island structure	Tg (°C) of cured body		130	135	125	128	132
	CTE1 (ppm/K) of cured body		15	13	15	16	16
	Phase separation		Caused	Caused	Caused	Caused	Caused
	Sea phase main component		Thermoplastic resin	Thermosetting resin	Thermoplastic resin	Thermoplastic resin	Thermoplastic resin
	Island phase main component		Thermosetting resin	Thermoplastic resin	Thermosetting resin	Thermosetting resin	Thermosetting resin
	Maximum diameter (μm) of particles of island phase		0.2	1.1	0.1	0.7	4.0
	Resin invasion amount (μm) to hollow region		10	40	7	12	16
	Resin invasion amount to hollow region (determination)		○	×	○	○	○

[0132]

Components used in Example 2 are as follows:

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: LVR8210DL, manufactured by Gunee Chemical Industry Co., Ltd. (novolak type phenolic resin; hydroxyl equivalent: 104 g/eq., and softening point: 60°C)

Thermoplastic resin: acrylic ester copolymer containing carboxyl groups; weight-average molecular weight: about 600,000, and glass transition temperature (T_g): -35°C

Filler 1: FB-9454FC, manufactured by Denka Co., Ltd. (average particle diameter: 19 μm)

Carbon black: #20, manufactured by Mitsubishi Chemical Corporation

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

[0133]

[Thermosetting-resin Sheet Production]

In accordance with blend proportions shown in Table 2, individual components were dissolved and dispersed in methyl ethyl ketone as a solvent to prepare a vanish having a concentration of 90% by weight. This vanish was applied onto a release-treated film which was a polyethylene terephthalate

film subjected to silicone release treatment and having a thickness of 38 μm . Thereafter, the resultant was dried at 110°C for 5 minutes. In this way, each sheet having a thickness of 65 μm was yielded. Four of the resultant sheets were laminated onto each other to yield a thermosetting-resin sheet having a thickness of 260 μm .

[0134]

[Cured Body Production]

A heating oven was used to heat and cure the thermosetting-resin sheet at 150°C for 1 hour. In this way, a cured body was yielded.

[0135]

[Evaluations]

Various evaluations were made about the thermosetting-resin sheet and the cured body. The results are shown in Table 2.

[0136]

[Table 2]

		Example 2	
Blend proportions (part(s) by weight)	Epoxy resin (YSLV-80XY)		6.3
	Phenolic resin (LVR8210DL)		3.4
	Thermoplastic resin		1.70
	Filler 1 (FB-9454FC)		88.0
	Carbon black (#20)		0.36
	Curing accelerator (2PHZ-PW)		0.24
Total			100.0
Thermoplastic resin content (% by weight) in entire components (100% by weight) other than filler			14.2
Filler content (% by volume) in thermosetting-resin sheet			80
Thermosetting-resin sheet thickness (μm)			260
Evaluations	Phase separation in thermosetting-resin sheet (B-stage)		Not caused
	Sea-island structure	Phase separation	Caused
		Sea phase main component	Thermoplastic resin
		Island phase main component	Thermosetting resin
		Maximum diameter (μm) of particles of island phase	0.2
	Hollow region	Gap width (μm)	20
		Invasion amount (μm)	10
		Determination	O

[0137]

Components used in Examples 3 and 4 are as follows:

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: LVR8210DL, manufactured by Guneei

Chemical Industry Co., Ltd. (novolak type phenolic resin;
hydroxyl equivalent: 104 g/eq., and softening point: 60°C)

Thermoplastic resin: acrylic ester copolymer containing
carboxyl groups; weight-average molecular weight: about
600,000, and glass transition temperature (T_g): -35°C)

Filler 1: FB-7SDC, manufactured by Denka Co., Ltd.
(average particle diameter: 6 μm)

Filler 2: SO-25R, manufactured by Admatechs Company
Limited (average particle diameter: 0.5 μm)

Carbon black: #20, manufactured by Mitsubishi Chemical
Corporation

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

[0138]

[Thermosetting-resin Sheet Production]

In each of the examples, in accordance with blend
proportions shown in Table 3, individual components were
dissolved and dispersed in methyl ethyl ketone as a solvent to
prepare a vanish having a concentration of 90% by weight. This
vanish was applied onto a release-treated film which was a
polyethylene terephthalate film subjected to silicone release
treatment and having a thickness of 38 μm. Thereafter, the
resultant was dried at 110°C for 5 minutes. In this way, each
sheet having a thickness of 65 μm was yielded. Four of the

resultant sheets were laminated onto each other to yield a thermosetting-resin sheet having a thickness of 260 μm .

[0139]

[Cured Body Production]

A heating oven was used to heat and cure the thermosetting-resin sheet at 150°C for 1 hour. In this way, a cured body was yielded.

[0140]

[Evaluations]

Various evaluations were made about the thermosetting-resin sheet and the cured body. The results are shown in Table 3.

[0141]

[Table 3]

		Example 3	Example 4	
Blend proportions (part(s) by weight)	Epoxy resin (YSLV-80XY)	11.0	7.6	
	Phenolic resin (LVR8210DL)	6.1	4.2	
	Thermoplastic resin	3.2	2.2	
	Filler 1 (FB-7SDC)	62.4	67.4	
	Filler 2 (SO-25R)	16.6	17.9	
	Carbon black (#20)	0.56	0.56	
	Curing accelerator (2PHZ-PW)	0.14	0.14	
Total		100.0	100.0	
Thermoplastic resin content (% by weight) in entire components (100% by weight) other than fillers		15.2	15.0	
Filler content (% by volume) in thermosetting-resin sheet		67.2	76	
Thermosetting-resin sheet thickness (μm)		260	260	
Evaluations	Phase separation in thermosetting resin sheet (B-stage)		Not caused	Not caused
	Sea-island structure	Phase separation	Caused	Caused
		Sea phase main component	Thermoplastic resin	Thermoplastic resin
		Island phase main component	Thermosetting resin	Thermosetting resin
		Maximum diameter (μm) of particles of island phase	0.2	0.2
	Hollow region	Gap width (μm)	20	20
		Invasion amount (μm)	12	8
		Determination	○	○

[0142]

Components used in Examples 5 and 6 are as follows:

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: LVR8210DL, manufactured by Gunee Chemical Industry Co., Ltd. (novolak type phenolic resin; hydroxyl equivalent: 104 g/eq., and softening point: 60°C)

Thermoplastic resin: acrylic ester copolymer containing carboxyl groups; weight-average molecular weight: about 600,000, and glass transition temperature (T_g): -35°C)

Filler 1: spherical fused silica (average particle diameter: 50 μm)

Carbon black: #20, manufactured by Mitsubishi Chemical Corporation

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

[0143]

[Thermosetting-resin Sheet Production]

In each of the examples, in accordance with blend proportions shown in Table 4, individual components were dissolved and dispersed in methyl ethyl ketone as a solvent to prepare a vanish having a concentration of 90% by weight. This vanish was applied onto a release-treated film which was a polyethylene terephthalate film subjected to silicone release treatment and having a thickness of 38 μm. Thereafter, the resultant was dried at 110°C for 5 minutes. In this way, each sheet having a thickness of 65 μm was yielded. Four of the resultant sheets were laminated onto each other to yield a

thermosetting-resin sheet having a thickness of 260 μm .

[0144]

[Cured Body Production]

A heating oven was used to heat and cure the thermosetting-resin sheet at 150°C for 1 hour. In this way, a cured body was yielded.

[0145]

[Evaluations]

Various evaluations were made about the thermosetting-resin sheet and the cured body. The results are shown in Table 4.

[0146]

[Table 4]

			Example 5	Example 6
Blend proportions (part(s) by weight)	Epoxy resin (YSLV-80XY)		13.2	10.5
	Phenolic resin (LVR8210DL)		7.3	5.8
	Thermoplastic resin		3.8	3.1
	Filler 1		75.0	80.0
	Carbon black (#20)		0.56	0.51
	Curing accelerator (2PHZ-PW)		0.14	0.09
Total			100.0	100.0
Thermoplastic resin content (% by weight) in entire components (100% by weight) other than filler			15.2	15.5
Filler content (% by volume) in thermosetting resin sheet			62.1	68.6
Thermosetting-resin sheet thickness (μm)			260	260
Evaluations	Phase separation in thermosetting resin sheet (B-stage)		Not caused	Not caused
	Sea-island structure	Phase separation	Caused	Caused
		Sea phase main component	Thermoplastic resin	Thermoplastic resin
		Island phase main component	Thermosetting resin	Thermosetting resin
		Maximum diameter (μm) of particles of island phase	0.2	0.2
	Hollow region	Gap width (μm)	20	20
		Invasion amount (μm)	18	15
		Determination	○	○

DESCRIPTION OF REFERENCE SIGNS

[0147]

2: Device mounted product

11: Thermosetting-resin sheet

12: Separator

22: Substrate
23: SAW chip
24: Bump electrode
25: Hollow region
26: Cured resin
31: Stacked body
32: Sealed body
33: Cured body
34: Hollow package
41: Lower heating plate
42: Upper heating plate

CLAIMS

1. A sealing thermosetting-resin sheet used to manufacture a hollow package,
wherein a cured body of the sealing thermosetting-resin sheet has a sea-island structure comprising a matrix part containing a first resin component as a main component, and a domain part containing a second resin component as a main component, and
wherein the matrix part is softer than the domain part.
2. The sealing thermosetting-resin sheet according to claim 1, wherein the cured body further comprises a filler dispersed in the matrix part.
3. The sealing thermosetting-resin sheet according to claim 1 or 2, comprising a thermoplastic resin and a thermosetting resin,
wherein the first resin component is the thermoplastic resin, and
wherein the second resin component is the thermosetting resin.
4. The sealing thermosetting-resin sheet according to any one of claims 1 to 3, wherein the domain part has a maximum

particle diameter of 0.01 μm to 5 μm .

5. The sealing thermosetting-resin sheet according to claim 3, wherein the thermoplastic resin has an acid value of 1 mgKOH/g to 100 mgKOH/g.

6. A hollow-package manufacturing method, comprising the step of pressuring a stacked body which comprises a device mounted product comprising an adherend and an electronic device mounted on the adherend, and further comprises a sealing thermosetting-resin sheet arranged over the device mounted product to form a sealed body which comprises the adherend, the electronic device mounted on the adherend, and the sealing thermosetting-resin sheet covering the electronic device,

wherein a cured body of the sealing thermosetting-resin sheet has a sea-island structure comprising a matrix part containing a first resin component as a main component, and a domain part containing a second resin component as a main component, and

wherein the matrix part is softer than the domain part.