

DESCRIPTION

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

TECHNICAL FIELD

[0001]

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

BACKGROUND ART

[0002]

In production of an electronic device package, a procedure is typically adopted in which one or a plurality of electronic devices that are fixed on a substrate, etc. are sealed with a sealing resin and a sealing body is deiced as necessary to form a package for every electronic device.

[0003]

The sealing resin as described above is normally stored in a refrigerated state or a frozen state. This is because a curing reaction gradually proceeds and the quality of the sealing resin degrades when the sealing resin is stored at normal temperature. However, it has been desired to improve normal temperature storage properties from the viewpoints of improving workability, etc.

PRIOR ART DOCUMENT

PATENT DOCUMENTS

[0004]

Patent Document 1: JP-A-2013-7028

Patent Document 2: JP-A-2006-19714

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0005]

Patent Document 1 describes that an epoxy resin, an inorganic filler, a curing accelerator, etc. are kneaded to prepare a kneaded product and the kneaded product is subjected to plastic processing to form a resin sheet. However, with the method of producing a resin sheet in Patent Document 1, a portion of the curing accelerator may become active due to an increase in temperature of the kneaded product at kneading. Once the curing accelerator becomes active, the active curing accelerator becomes a starting point of reaction and the curing reaction gradually proceeds even at normal temperature. Therefore, the normal temperature storage properties of the resin sheet deteriorate.

[0006]

Patent Document 2 describes that varnish containing a solvent, an epoxy resin, a curing accelerator, etc. is applied

on a film and the coating film is dried to form a resin sheet. However, in the method of producing a resin sheet (solvent application) in Patent Document 2, the curing accelerator has high affinity with the epoxy resin, etc. Therefore, the curing accelerator easily reacts with the epoxy resin, etc., and a portion of the curing accelerator may become active.

[0007]

The present invention solves the above-described problems, and an object thereof is to provide a resin sheet having excellent normal temperature storage properties.

MEANS FOR SOLVING THE PROBLEMS

[0008]

The present invention relates to a resin sheet for sealing an electronic device, having an exothermic onset temperature of 120°C or higher measured with a differential scanning calorimeter and an exothermic peak temperature of 150 to 200°C.

[0009]

Because the resin sheet for sealing an electronic device of the present invention satisfies the characteristics described above, a curing reaction does not practically proceed at normal temperature. Therefore, the resin sheet has excellent normal temperature storage properties.

[0010]

An area in a range of the exothermic peak temperature $\pm$

30°C in a DSC curve measured with the differential scanning calorimeter is preferably 70% or more to an entire exothermic peak area. The area is 70% or more, so that a steep exothermic peak of the DSC curve is formed in a high temperature region of the DSC curve. That is, a curing reaction does not practically proceed at normal temperature, and the resin sheet has excellent normal temperature storage properties.

[0011]

A minimum melt viscosity after the resin sheet is stored under a condition of 25°C for 4 weeks is preferably not more than 2 times the minimum melt viscosity before the storage. The minimum melt viscosity after the storage is not more than 2 times a minimum melt viscosity before the storage, a curing reaction at normal temperature is satisfactorily suppressed, and the resin sheet has excellent normal temperature storage properties.

[0012]

A content of filler in the resin sheet for sealing an electronic device is preferably 70 to 90% by volume.

[0013]

The resin sheet for sealing an electronic device is preferably obtained by subjecting a kneaded product obtained through kneading an epoxy resin, a phenol resin, a thermoplastic resin, a filler, and a curing accelerator to plastic processing to form the kneaded product into a sheet shape. According to

this method, the curing accelerator has lower affinity with the epoxy resin, etc. as compared with solvent application method, and the curing accelerator is relatively difficult to react with the epoxy resin, etc. Therefore, the normal temperature storage properties can be improved.

[0014]

The curing accelerator is preferably an imidazole curing accelerator. The imidazole curing accelerator is preferably a latent curing accelerator.

[0015]

The present invention also relates to a method of manufacturing an electronic device package, the method including a laminating step of laminating the resin sheet for sealing an electronic device on one or a plurality of electronic devices so as to cover the electronic devices; and a sealing body forming step of curing the resin sheet for sealing an electronic device to form a sealing body.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

Fig. 1 is a cross-sectional view schematically showing a resin sheet according to one embodiment of the present invention.

Fig. 2A is a view schematically showing one step of a method of manufacturing an electronic device package according

to one embodiment of the present invention.

Fig. 2B is a view schematically showing one step of the method of manufacturing an electronic device package according to one embodiment of the present invention.

Fig. 2C is a view schematically showing one step of the method of manufacturing an electronic device package according to one embodiment of the present invention.

MODE FOR CARRYING OUT THE INVENTION

[0017]

The present invention will be explained in detail with reference to embodiments below; however, the invention is not limited only to these embodiments.

[0018]

[Resin sheet for sealing electronic device]

[0019]

Fig. 1 is a cross-sectional view schematically showing a resin sheet 11 according to one embodiment of the present invention. The resin sheet 11 is typically provided in a form in which the resin sheet 11 is laminated on a support 11a such as a polyethylene terephthalate (PET) film. A release treatment may be performed on the support 11a to easily peel the sealing sheet 11.

[0020]

The resin sheet 11 has an exothermic onset temperature

of 120°C or higher measured with a differential scanning calorimeter (DSC), and has an exothermic peak temperature of 150 to 200°C.

[0021]

The resin sheet 11 has an exothermic onset temperature of 120°C or higher, and an exothermic peak temperature of 150 to 200°C, so that a curing reaction does not practically proceed at normal temperature. Therefore, the resin sheet 11 has excellent normal temperature storage properties.

[0022]

The upper limit of the exothermic onset temperature is not especially limited; however, it is for example 170°C or lower from the viewpoints of the manufacturing cost and manufacturing efficiency of the resin sheet.

[0023]

The exothermic peak temperature is preferably 160°C or higher, and preferably 190°C or lower.

[0024]

The exothermic onset temperature and the exothermic peak temperature can be measured with methods described in the examples.

[0025]

The exothermic onset temperature and the exothermic peak temperature can be controlled by the kind of the curing accelerator.

[0026]

The area in a range of the exothermic peak temperature $\pm 30^{\circ}\text{C}$ in a DSC curve measured with a differential scanning calorimeter is preferably 70% or more, and more preferably 80% or more to the entire exothermic peak area. If the area is 70% or more, a steep exothermic peak of the DSC curve is formed in a high temperature region of the DSC curve. That is, a curing reaction does not practically proceed at normal temperature, and the resin sheet 11 has excellent normal temperature storage properties.

[0027]

The minimum melt viscosity after the resin sheet is stored under a condition of 25°C for 4 weeks is preferably not more than 2 times, and more preferably not more than 1.5 times the minimum melt viscosity before the storage. If the minimum melt viscosity after the storage is not more than 2 times the minimum melt viscosity before the storage, a curing reaction at normal temperature is satisfactorily suppressed, and the resin sheet 11 has excellent normal temperature storage properties.

The minimum melt viscosity can be measured with the method described in the examples.

[0028]

The minimum melt viscosity before the storage is not especially limited; however, it is normally 20 to 20,000 Pa·s, and preferably 3,000 to 10,000 Pa·s.

[0029]

The method of manufacturing the resin sheet 11 is not especially limited; however, preferred is a method of subjecting a kneaded product obtained through kneading an epoxy resin, a phenol resin, a thermoplastic resin, a filler, and a curing accelerator to plastic processing to form the kneaded product into a sheet shape. According to this method, the curing accelerator has lower affinity with the epoxy resin, etc. as compared with solvent application method, and the curing accelerator is relatively difficult to react with the epoxy resin, etc. Therefore, the normal temperature storage properties can be improved.

[0030]

Specifically, an epoxy resin, a phenol resin, a thermoplastic resin, a filler, and a curing accelerator are melt-kneaded with a known kneader such as a mixing roll, a pressure kneader, or an extruder to prepare a kneaded product, and the obtained kneaded product is subjected to plastic processing to form the kneaded product into a sheet shape. For the kneading condition, the upper limit of the temperature is preferably 140°C or lower, and more preferably 130°C or lower. The upper limit of the temperature is 140°C or lower, so that the curing accelerator can be suppressed from becoming active in the process of manufacturing the resin sheet, and good normal temperature storage properties can be obtained. The lower

limit of the temperature is preferably the softening point or higher of each component described above, and it is for example 30°C or higher, and preferably 50°C or higher.

[0031]

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.

[0032]

The epoxy resin is preferably an epoxy resin which is in a solid form at room temperature, and has an epoxy equivalent of 150 to 250 and a softening point or melting point of 50°C to 130°C in order to certainly attain a desired toughness after curing and reactivity. Particularly preferred are triphenylmethane type epoxy resin, cresol novolak type epoxy resin, and biphenyl type epoxy resin from the viewpoint of the reliability.

[0033]

The phenol 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.

[0034]

The phenol 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 phenol resin is in particular preferably phenol novolak resin because the resin is high in curing reactivity. Moreover, from the viewpoint of the reliability, the phenol resin is a low-hygroscopicity phenolic resin such as phenol aralkyl resin, or biphenyl aralkyl resin can be preferably used.

[0035]

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 methylmethacrylate-butadiene-styrene copolymer (MBS resin). These thermoplastic resins may be used alone or in combination

of two or more thereof. Among these, a styrene-isobutylene-styrene block copolymer is preferable from the viewpoint of its low stress property and low moisture absorption. In addition, an MBS resin is preferable because friction between the MBS resin and other resins such as an epoxy resin and a phenol resin is small and the kneading can be performed in a mild temperature condition (condition of relatively low temperature).

[0036]

The average particle size of the thermoplastic resin is not especially limited; however, it is preferable to use a thermoplastic resin having a relatively small average particle size. For example, the average particle size is 5 to 500 μm , and preferably 50 to 200 μm . This makes it possible to perform the kneading in a mild temperature condition (condition of relatively low temperature).

For example, the average particle size can be obtained by measurement on a sample that is extracted arbitrarily from the population using a laser diffraction-scattering type particle size distribution measuring apparatus.

[0037]

The filler is not especially limited; however, an inorganic filler is preferable. Examples of the inorganic filler include quartz glass, talc, silica (fused silica, crystalline silica, etc.), alumina, aluminum nitride, silicon

nitride, and boron nitride. Among these, silica and alumina are preferable, and silica is more preferable because the linear expansion coefficient can be satisfactorily decreased. As silica, fused silica is preferable, and spherical fused silica is more preferable because of excellent fluidity.

[0038]

The filler has an average particle size of preferably 1 μm or more, and more preferably 5 μm or more. If the average particle size is 1 μm or more, the flexibility of the resin sheet can be easily achieved. The filler has an average particle size of preferably 40 μm or less, and more preferably 30 μm or less. If the average particle size is 40 μm or less, the filler can be easily filled at a high rate.

For example, the average particle size can be obtained by measurement on a sample that is extracted arbitrarily from the population using a laser diffraction-scattering type particle size distribution measuring apparatus.

[0039]

The filler is preferably treated (pre-treated) with a silane coupling agent. This makes it possible to improve the wettability of the filler to the resin, and to perform the kneading in a mild temperature condition (condition of relatively low temperature).

[0040]

The silane coupling agent is a compound having a

hydrolyzable group and an organic functional group in a molecule.

[0041]

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.

[0042]

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

[0043]

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.

[0044]

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.

[0045]

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.

[0046]

The curing accelerator is not especially limited as long as it promotes curing of the epoxy resin and the phenol resin, and examples of the curing accelerator include phosphorous-boron curing accelerators such as tetraphenylphosphonium tetraphenylborate (trade name; TPP-K), tetraphenylphosphonium tetra-p-triborate (trade name; TPP-MK), and triphenylphosphine triphenylborane (trade name; TPP-S) (all of these are manufactured by Hokko Chemical Industry Co., Ltd.).

[0047]

Examples of the curing accelerator include imidazole 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),

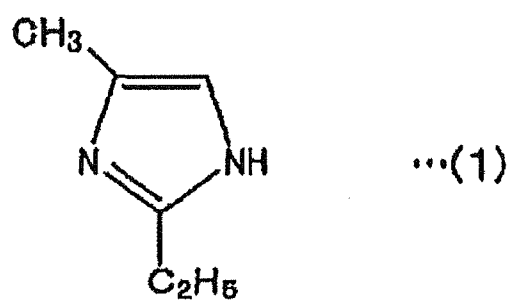
2-ethyl-4-methylimidazole (trade name; 2E4MZ),
 2-phenylimidazole (trade name; 2PZ),
 2-phenyl-4-methylimidazole (trade name; 2P4MZ),
 1-benzyl-2-methylimidazole (trade name; 1B2MZ),
 1-benzyl-2-phenylimidazole (trade name; 1B2PZ),
 1-cyanoethyl-2-methylimidazole (trade name; 2MZ-CN),
 1-cyanoethyl-2-undecylimidazole (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
 triazine (trade name; 2E4MZ-A), a
 2,4-diamino-6-[2'-methylimidazolyl-(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;
 2P4MHZ-PW) (all of these are manufactured by Shikoku Chemicals
 Corporation).

[0048]

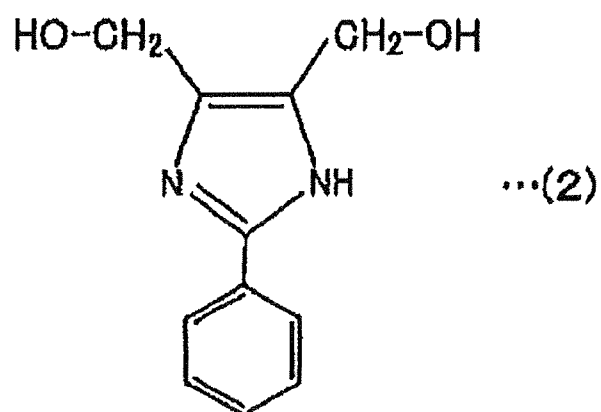
Examples of the imidazole curing accelerator include an
 inclusion complex composed of 5-nitroisophthalic acid and an
 imidazole compound represented by Formula (1), an inclusion

complex composed of 5-nitroisophthalic acid and an imidazole compound represented by Formula (2), and an inclusion complex composed of 5-nitroisophthalic acid and an imidazole compound represented by Formula (3)

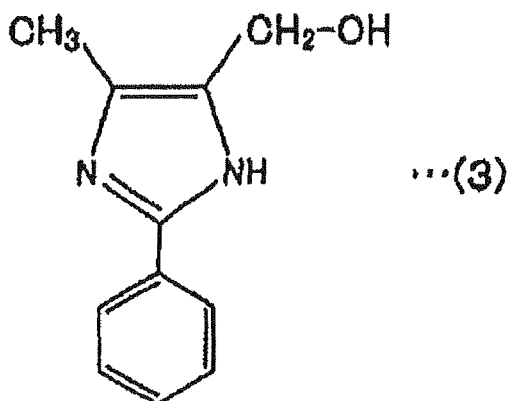
[Formula 1]



[Formula 2]



[Formula 3]



[0049]

An inclusion complex is a complex that is formed when each of guest compounds (imidazole compounds represented by Formulas (1) to (3)) is included (entrapped) by a host compound (5-nitroisophthalic acid). The host compound as used herein bonds to each of the guest compounds by intermolecular force other than covalent bond (other than chemical bond) to form compounds, and in the compounds, the inclusion complex is a compound that forms an inclusion lattice. The inclusion lattice is such that the host compounds are bonded to each other through a bond other than covalent bond, and each of the guest compounds is included in a space (gap) of two or more molecules of the bonded host compounds by bond (intermolecular force) other than covalent bond. The inclusion complex is a compound having such inclusion lattice.

[0050]

In these inclusion complexes, the imidazole compounds represented by Formulas (1) to (3) that serve as guest compounds

are included in 5-nitroisophthalic acid that serves as a host compound by physical force such as intermolecular force not by chemical bond. Accordingly, these inclusion complexes do not act as a curing accelerator at normal temperature; however, they activate as a curing agent when the inclusion lattice is removed at high temperature.

[0051]

For example, the inclusion complex can be produced as follows. That is, 5-nitroisophthalic acid and at least one selected from the group consisting of the imidazole compounds represented by Formulas (1) to (3) are added to a solvent, and the mixture is subjected to heating treatment or heating reflux treatment while appropriately stirring the mixture to precipitate the targeted inclusion complex.

[0052]

When the easiness of dissolution of the components to the solvent is considered, 5-nitroisophthalic acid and the imidazole compounds represented by Formulas (1) to (3) are separately dissolved into a solvent, and then these individual solutions are preferably mixed together. Examples of the solvent that can be used include water, methanol, ethanol, ethyl acetate, methyl acetate, diethyl ether, dimethyl ether, acetone, methylethylketone, and acetonitrile.

[0053]

With regard to the addition ratio between

5-nitroisophthalic acid and the imidazole compounds represented by Formulas (1) to (3) during manufacturing of inclusion complex, the imidazole compounds (guest compounds) represented by Formulas (1) to (3) is preferably for example 0.1 to 5.0 mol, and more preferably 0.5 to 3.0 mol to 1 mol of 5-nitroisophthalic acid (host compound).

[0054]

The heating condition during manufacturing of inclusion complex may fall within a range of temperature in which the targeted inclusion complex is obtained. For example, the heating can be performed preferably in a range of 40 to 120°C, and more preferably in a range of 50 to 90°C.

[0055]

The heating during manufacturing of inclusion complex is preferably performed while stirring a solution or a suspension containing 5-nitroisophthalic acid and the imidazole compounds represented by Formulas (1) to (3), and the refluxing under heat is more preferably performed.

[0056]

After the heating treatment or the heating reflux treatment, for example, the solution or the suspension is left at room temperature for overnight to precipitate an inclusion complex, and is filtered and dried to obtain the targeted inclusion complex.

[0057]

Among the imidazole curing accelerators, a latent curing accelerator is preferable because the latent curing accelerator is difficult to be activated even at kneading temperature, and 2-phenyl-4,5-dihydroxymethylimidazole, an inclusion complex composed of 5-nitroisophthalic acid and the imidazole compound represented by Formula (1), an inclusion complex composed of 5-nitroisophthalic acid and the imidazole compound represented by Formula (2), and an inclusion complex composed of 5-nitroisophthalic acid and the imidazole compound represented by Formula (3) are more preferable.

[0058]

A flame retardant component, a pigment, a silane coupling agent, etc. are preferably kneaded together with the epoxy resin, the phenol resin, the thermoplastic resin, the filler, and the curing accelerator.

[0059]

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.

[0060]

The pigment is not especially limited, and an example

thereof includes carbon black.

[0061]

The kneading time is preferably 1 minute or more, and more preferably 30 minutes or more. The kneading time is preferably 30 minutes or less, and more preferably 15 minutes or less.

[0062]

The kneading is preferably performed under a reduced pressure condition (under a reduced pressure atmosphere). The pressure under the reduced pressure condition is preferably 0.1 kg/cm² or less, and more preferably 0.05 kg/cm² or less. The lower limit of the pressure under reduced pressure is not especially limited; however, it is 1×10^{-4} kg/cm² or more.

[0063]

The kneaded product after melt-kneading is preferably subjected to plastic processing in a high temperature state without being cooled. The plastic processing is not especially limited, and examples thereof include a plate pressing method, a T-die extrusion method, a screw-die extrusion method, a rolling method, a roll kneading method, an inflation extrusion method, a co-extrusion method and a calendar molding method. The plastic processing temperature is preferably the softening point or higher of each component described above. When the thermosetting property and moldability of the epoxy resin are considered, the temperature is for example 40 to 150°C, preferably 50 to 140°C, and more preferably 70 to 120°C.

[0064]

The thickness of the resin sheet 11 is not especially limited; however, it is preferably 100 μm or more, and more preferably 150 μm or more. The thickness of the resin sheet 11 is preferably 2,000 μm or less, and more preferably 1,000 μm or less. If the thickness falls within the above-described range, an electronic device can be satisfactorily sealed.

[0065]

The resin sheet 11 may have a single-layered structure or may have a multilayered structure in which two or more resin sheets are laminated; however, a single-layered structure is preferable because there is no possibility of interlayer peeling and high uniformity in thickness of the sheet can be achieved.

[0066]

Next, the composition of the resin sheet 11 will be explained.

[0067]

The total content of the epoxy resin and the phenol resin in the resin sheet 11 is preferably 2.0% by weight or more, and more preferably 3.0% by weight or more. If the total content is 2.0% by weight or more, the adhering strength of the resin sheet 11 to the electronic device, the substrate, etc. can be suitably obtained. The total content of the epoxy resin and the phenol resin in the resin sheet 11 is preferably 20% by weight

or less, and more preferably 10% by weight or less. If the total content is 20% by weight or less, the moisture absorption can be kept low.

[0068]

With regard to the compounding ratio between the phenol resin and the epoxy resin, the epoxy resin and the phenol resin are preferably compounded so that the total amount of the hydroxyl group in the phenol resin is 0.7 to 1.5 equivalents, and more preferably 0.9 to 1.2 equivalents to 1 equivalent of the epoxy group in the epoxy resin from the viewpoint of the curing reactivity.

[0069]

The content of the thermoplastic resin in the resin sheet 11 is preferably 1.0% by weight or more, and more preferably 1.5% by weight or more. If the content is 1.0% by weight or more, the kneading can be performed in a mild temperature condition (a condition of relatively low temperature). The content of the thermoplastic resin in the resin sheet 11 is preferably 3.5% by weight or less, and more preferably 3% by weight or less. If the content is 3.5% by weight or less, the adhering strength of the resin to the electronic device, the substrate, etc. can be satisfactorily obtained.

[0070]

The content of the filler in the resin sheet 11 is preferably 70% by volume or more, and more preferably 74% by

volume or more. If the content is 70% by volume or more, the linear expansion coefficient can be designed to be low. On the other hand, the content of the filler is preferably 90% by volume or less, and more preferably 85% by volume or less. If the content is 90% by volume or less, flexibility, fluidity, and adhesion can be suitably obtained.

[0071]

The content of the filler can be also explained by using "% by weight" as a unit. The content of silica is explained typically by using "% by weight" as a unit.

Silica normally has a specific gravity of 2.2 g/cm^3 . Therefore, the preferred range of the content (% by weight) of silica is as follows.

That is, the content of silica in the resin sheet 11 is preferably 81% by weight or more, and more preferably 84% by weight or more. The content of silica in the resin sheet 11 is preferably 94% by weight or less, and more preferably 91% by weight or less.

[0072]

Alumina normally has a specific gravity of 3.9 g/cm^3 . Therefore, the preferred range of the content (% by weight) of alumina is as follows.

That is, the content of alumina in the resin sheet 11 is preferably 88% by weight or more, and more preferably 90% by weight or more. The content of alumina in the resin sheet 11

is preferably 97% by weight or less, and more preferably 95% by weight or less.

[0073]

The content of the curing accelerator is preferably 0.1 parts by weight or more, more preferably 1 part by weight or more, and further preferably 3 parts by weight or more to the total 100 parts by weight of the epoxy resin and the phenol resin. If the content is 0.1 parts by weight or more, the curing completes within a practical time. The content of the curing accelerator is preferably 15 parts by weight or less, more preferably 10 parts by weight or less, and further preferably 8 parts by weight or less. If the content is 15 parts by weight or less, good strength of the cured product can be obtained.

[0074]

The content of the flame retardant component is preferably 10% by weight or more, and more preferably 15% by weight or more in 100% by weight of the organic component (the entire components excluding filler). If the content is 10% by weight or more, the flame retardance can be obtained satisfactorily. The content of the flame retardant component is preferably 30% by weight or less, and more preferably 25% by weight or less. If the content is 30% by weight or less, deterioration in physical properties (specifically, deterioration in physical properties such as glass transition temperature and resin strength at high temperature) of the cured

product tends to be suppressed.

[0075]

The content of the pigment in the resin sheet 11 is preferably 0.1 to 2 parts by weight.

[0076]

The resin sheet 11 is used to seal an electronic device such as a SAW (Surface Acoustic Wave) filter; MEMS (Micro Electro Mechanical Systems) such as a pressure sensor and a vibration sensor; semiconductors such as an IC (Integrated Circuit) including an LSI, and a transistor; a capacitor; and a resistor. Among these, the resin sheet 11 can be suitably used for sealing an electronic device (specifically, an SAW filter and MEMS) that requires hollow sealing, and can be especially suitably used for sealing a SAW filter.

[0077]

The sealing method is not especially limited. An example thereof includes a method of laminating the resin sheet 11 that is not cured on a substrate so that the resin sheet 11 covers an electronic device on the substrate and curing the resin sheet 11 to seal the electronic device. The substrate is not especially limited, and examples thereof include a printed circuit board, a ceramic substrate, a silicon substrate, and a metal substrate.

[0078]

[Method of manufacturing electronic device package]

Each of Figs. 2A to 2C is a view schematically showing one step of a method of manufacturing an electronic device package according to one embodiment of the present invention. In the present embodiment, hollow sealing is performed on a SAW filter 13 that is mounted on a printed circuit board 12 by using the resin sheet 11 to produce an electronic device package 18.

[0079]

(SAW filter mounted substrate preparing step)

In the SAW filter mounted substrate preparing step, the printed circuit board 12 is prepared on which a plurality of the SAW filters 13 are mounted (refer to Fig. 2A). A piezoelectric crystal in which a prescribed comb-shaped electrode is formed is diced into individual pieces with a known method to form the SAW filter 13. The SAW filter 13 can be mounted on the printed circuit board 12 with a known apparatus such as a flip-chip bonder or a die bonder. The SAW filter 13 is electrically connected to the printed circuit board 12 through a projected electrode 13a such as a bump. A hollow part 14 is maintained between the SAW filter 13 and the printed circuit board 12 so as not to inhibit propagation of a surface acoustic wave on the surface of the SAW filter. The distance between the SAW filter 13 and the printed circuit board 12 can be appropriately set, and is generally about 15 to 50 μm .

[0080]

(Sealing step)

In the sealing step, the resin sheet 11 is laminated on the printed circuit board 12 so that the resin sheet 11 covers the SAW filter 13 to perform resin sealing on the SAW filter 13 with the resin sheet 11 (refer to Fig. 2B). The resin sheet 11 functions as a sealing resin for protecting the SAW filter 13 and the elements attached to the filter from the external environment.

[0081]

The method of laminating the resin sheet 11 on the printed circuit board 12 is not especially limited, and a known method can be used such as hot press or laminator. For the hot pressing condition, the temperature is for example 40 to 100°C, and preferably 50 to 90°C; the pressure is for example 0.1 to 10 MPa, and preferably 0.5 to 8 MPa; and the duration is for example 0.3 to 10 minutes, and preferably 0.5 to 5 minutes. In consideration of improvement of the tackiness and followability of the resin sheet 11 to the SAW filter 13 and the printed circuit board 12, pressing is preferably performed under a reduced pressure condition (for example 0.1 to 5 kPa).

[0082]

(Sealing body forming step)

In the sealing body forming step, the resin sheet 11 is subjected to a thermal curing treatment to form a sealing body 15 (refer to Fig. 2B).

[0083]

For a condition of the thermal curing treatment, the heating temperature is preferably 100°C or higher, and more preferably 120°C or higher. On the other hand, the upper limit of the heating temperature is preferably 200°C or lower, and more preferably 180°C or lower. The heating time is preferably 10 minutes or more, and more preferably 30 minutes or more. On the other hand, the upper limit of the heating time is preferably 180 minutes or less, and more preferably 120 minutes or less. A pressure may be applied as necessary. The pressure is preferably 0.1 MPa or more, and more preferably 0.5 MPa or more. On the other hand, the upper limit of the pressure is preferably 10 MPa or less, and more preferably 5 MPa or less.

[0084]

(Dicing step)

Subsequently, the sealing body 15 may be diced (refer to Fig. 2C). This makes it possible to provide an electronic device package 18 for each SAW filter 13.

[0085]

(Substrate mounting step)

A rewiring and a bump are formed for the electronic device package 18 as necessary to perform the substrate mounting step of mounting the electronic device package 18 to a separate substrate (not shown in the drawing). The electronic device package 18 can be mounted to the substrate by using a known apparatus such as a flip-chip bonder or a die bonder.

EXAMPLES

[0086]

The preferred examples of this invention will be explained in detail below. However, the materials, the compounding amounts, etc. described in the examples are not intended to be limited only thereto in the scope of this invention unless otherwise specified.

[0087]

The components used in the examples will be explained.

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

Phenol resin: MEH-7851-SS manufactured by Meiwa Plastic Industries, Ltd. (phenol resin having biphenylaralkyl skeleton, hydroxyl group equivalent 203 g/eq., softening point 67°C)

Thermoplastic resin: Metablen C-132E manufactured by Mitsubishi Rayon Co., Ltd. (MBS resin, average particle size 120 μm)

Filler: FB-9454FC manufactured by DENKI KAGAKU KOGYO KABUSHIKI KAISHA (fused spherical silica, average particle size 20 μm)

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

Filler treated with silane coupling agent: FB-9454FC

manufactured by DENKI KAGAKU KOGYO KABUSHIKI KAISHA (fused spherical silica, average particle size 20 μm) treated with KBM-403 manufactured by Shin-Etsu Chemical Co., Ltd.

(3-glycidoxypopyl trimethoxysilane) (87.9 parts by weight of FB-9454FC is treated with 0.5 parts by weight of KBM-403)

Carbon black: #20 manufactured by Mitsubishi Chemical Corporation

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

Curing accelerator 1: 2PHZ-PW manufactured by Shikoku Chemicals Corporation

(2-phenyl-4,5-dihydroxymethylimidazole)

Curing accelerator 2 (inclusion complex): an inclusion complex composed of 5-nitroisophthalic acid and 2-ethyl-4-methylimidazole represented by Formula (1)

Curing accelerator 3 (inclusion complex): an inclusion complex composed of 5-nitroisophthalic acid and 2-phenyl-4,5-dihydroxymethylimidazole represented by Formula (2)

Curing accelerator 4 (inclusion complex): an inclusion complex composed of 5-nitroisophthalic acid and 2-phenyl-4-methyl-5-hydroxymethylimidazole represented by Formula (3)

Curing accelerator 5: TPP manufactured by Hokko Chemical Industry Co., Ltd. (triphenylphosphine)

Curing accelerator 6: 2E4MZ manufactured by Shikoku Chemicals Corporation (2-ethyl-4-methylimidazole)

[0088]

Examples and Comparative Examples

Each of the components was compounded according to the compounding ratio described in Table 1, and the components were melt-kneaded at 60 to 120°C for 10 minutes under a reduced pressure condition (0.01 kg/cm²) with a roll kneader to prepare a kneaded product. Next, the obtained kneaded product was formed into a sheet shape by flat plate pressing to produce a resin sheet having a thickness of 200 μm.

[0089]

The following evaluations were performed using the obtained resin sheets (non-cured products). The results are shown in Table 1.

[0090]

[Exothermic onset temperature and exothermic peak temperature]

Each of the resin sheets was punched out to produce a circular sample with a diameter of 4 mm. A DSC curve of this sample was drawn by increasing temperature from -50°C to 300°C at a rate of 10°C/min using a differential scanning calorimeter (DSC Q2000 manufactured by TA Instruments), and the exothermic onset temperature and the exothermic peak temperature were read from the drawn DSC curve. A tangential line was drawn to the exothermic curve at the temperature at which the secondary

differential value of the exothermic curve became zero, and the temperature was read which corresponds to an intersection of the tangential line and the base line to obtain the exothermic onset temperature.

[0091]

[Ratio of heating value at exothermic peak temperature $\pm 30^{\circ}\text{C}$]

The area in a range of the exothermic temperature $\pm 30^{\circ}\text{C}$ (Area A) and the entire area of exothermic peak (Area B) were obtained from the drawn DSC curve. Then, the ratio of the heating value at the exothermic peak temperature $\pm 30^{\circ}\text{C}$ was calculated using the following equation.

$$\text{Ratio (\% of Heating Value at Exothermic Peak Temperature} \\ \pm 30^{\circ}\text{C} = (\text{Area A} / \text{Area B}) \times 100$$

[0092]

[Minimum melt viscosity before storage]

The minimum melt viscosity of each of the resin sheets was measured using a dynamic viscoelasticity measuring apparatus (ARES manufactured by TA Instruments). (Measurement conditions: gap of 1 mm, diameter of parallel plate of 8 mm, frequency of 0.1 Hz, and rising temperature rate of $10^{\circ}\text{C}/\text{min}$ from 50°C to 150°C)

[0093]

[Minimum melt viscosity after storage]

The minimum melt viscosity of each of the resin sheets after being stored at 25°C for 4 weeks was measured in the same

manner as in the case of before storage.

[0094]

[Table 1]

		Example 1	Example 2	Example 3	Example 4	Example 5	Comparative Example 1	Comparative Example 2
Compounding Ratio (parts by weight)	Epoxy Resin	3.4	3.4	3.4	3.4	3.4	3.4	3.4
	Phenol Resin	3.6	3.6	3.6	3.6	3.6	3.6	3.6
	Thermoplastic Resin	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	Filler	87.9	87.9	87.9	87.9	-	87.9	87.9
	Silane Coupling Agent	0.5	0.5	0.5	0.5	-	0.5	0.5
	Filler Treated with Silane Coupling Agent	-	-	-	-	88.4	-	-
	Carbon Black	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Flame Retardant	1.8	1.2	1.2	1.2	1.8	1.8	1.8
	Curing Accelerator 1	0.4	-	-	-	0.4	-	-
	Curing Accelerator 2 (Inclusion complex)	-	1.0	-	-	-	-	-
	Curing Accelerator 3 (Inclusion complex)	-	-	1.0	-	-	-	-
	Curing Accelerator 4 (Inclusion complex)	-	-	-	1.0	-	-	-
	Curing Accelerator 5	-	-	-	-	-	0.4	-
	Curing Accelerator 6	-	-	-	-	-	-	0.4
Total		98.2	100.0	100.0	100.0	98.2	98.2	98.2
Manufacturing Method		Kneading	Kneading	Kneading	Kneading	Kneading	Kneading	Kneading
Content (% by volume) of Filler in Resin Sheet		80	80	80	80	81	80	80
Evaluation	Exothermic Onset Temperature (°C)	141	135	150	147	139	110	115
	Exothermic Peak Temperature (°C)	181	172	189	183	179	145	150
	Ratio (%) of Heating Value at Exothermic Peak Temperature $\pm$ 30°C	87	85	92	83	87	68	65
	Minimum Melt Viscosity (Pa's) before Storage	6000	6800	6200	6300	7000	14000	17000
	Minimum Melt Viscosity (Pa's) after Storage	7200	9500	6400	7000	8000	Incapable of measurement	Incapable of measurement

[0095]

The rein sheets of Examples 1 to 5 having an exothermic onset temperature of 120°C or higher and an exothermic peak temperature of 150 to 200°C had a small change of minimum melt viscosity before and after storage at normal temperature, and were excellent in normal temperature storage properties. On the other hand, the curing reaction of the resin sheets of Comparative Examples 1 and 2 having an exothermic onset temperature of lower than 120°C proceeded during storage at normal temperature, and the minimum melt viscosity could not be measured.

[0096]

A filler treated with silane coupling agent was used in place of the non-treated filler to suppress a change of the minimum melt viscosity before and after storage (Example 5).

DESCRIPTION OF REFERENCE SIGNS

[0097]

- 11 Resin Sheet
- 11a Support
- 13 SAW Filter
- 14 Hollow Part
- 15 Sealing Body
- 18 Electronic Device Package

CLAIMS

1. A resin sheet for sealing an electronic device, having an exothermic onset temperature of 120°C or higher measured with a differential scanning calorimeter and an exothermic peak temperature of 150 to 200°C.

2. The resin sheet for sealing an electronic device according to claim 1, wherein an area in a range of the exothermic peak temperature $\pm 30^{\circ}\text{C}$ in a DSC curve measured with the differential scanning calorimeter is 70% or more to an entire exothermic peak area.

3. The resin sheet for sealing an electronic device according to claim 1 or 2, wherein a minimum melt viscosity after the resin sheet is stored under a condition of 25°C for 4 weeks is not more than 2 times a minimum melt viscosity before the storage.

4. The resin sheet for sealing an electronic device according to any of claims 1 to 3, wherein a content of filler in the resin sheet for sealing an electronic device is 70 to 90% by volume.

5. The resin sheet for sealing an electronic device

according to any of claims 1 to 4, which is obtained by subjecting a kneaded product obtained through kneading an epoxy resin, a phenol resin, a thermoplastic resin, a filler, and a curing accelerator to plastic processing to form the kneaded product into a sheet shape.

6. The resin sheet for sealing an electronic device according to any of claims 1 to 5, wherein the curing accelerator is an imidazole curing accelerator.

7. The resin sheet for sealing an electronic device according to any of claims 1 to 6, wherein the imidazole curing accelerator is a latent curing accelerator.

8. A method of manufacturing an electronic device package, the method comprising:

a laminating step of laminating the resin sheet for sealing an electronic device according to any of claims 1 to 7 on one or a plurality of electronic devices so as to cover the electronic devices; and

a sealing body forming step of curing the resin sheet for sealing an electronic device to form a sealing body.