CURABLE RESIN COMPOSITION, ELECTRONIC COMPONENT DEVICE, AND PRODUCTION METHOD FOR ELECTRONIC COMPONENT DEVICE

Technical Field

[0001] The present invention relates to a curable resin composition, an electronic component device, and a production method for an electronic component device.

[0002] A package (electronic component device), in which elements such as transistors and ICs (Integrated Circuits) are sealed with a sealing material including a curable resin such as epoxy resin, has been widely used in electronic equipment.

[0003] Recently, reduction in the thickness of electronic component devices has been ongoing in order to meet the requirements for reductions in the size and weight of electronic equipment. As a result, electronic component devices are becoming more susceptible to warping due to a difference in the thermal expansion rate of a sealing material and a substrate. Therefore, research has been conducted on the composition of sealing materials from the viewpoint of suppressing the amount of warping of electronic component devices (see, for example, Patent Document 1).

Related Art Documents

Patent Document

[0004] Patent Document 1: Japanese Patent Application Laid-Open (JP-A) No. 2005-29641

SUMMARY OF INVENTION

Technical Problem

[0005] A package having a PoP (Package on Package) structure, in which a package including a memory chip is provided over a package in which an application processor is sealed, is generally produced by inserting a bonding material such as solder balls between the packages and heating to melt the bonding material. During the heating, the lower package and the upper package may exhibit different warping behaviors and may not be sufficiently bonded to each other. Therefore, regulating the warping of one package to conform to the warping of the other package, instead of simply suppressing the warping of the packages, may be desirable in some cases.

[0006] In view of the above, an object of the present invention is to provide a cured resin composition that can regulate the warping of a package in a suitable manner. Another object of the present invention is to provide an electronic component device and a production method thereof, in which the curable resin composition is used.

Solution to Problem

[0007] The means for solving the above-mentioned problem includes the following embodiments.

<1> A curable resin composition, comprising a curable resin component, triphenylphosphine oxide, and a filler, the triphenylphosphine oxide being included in the curable resin composition in an amount of 0.3% by mass or more.

<1a> Disclosed herein is a curable resin composition, comprising a curable resin component, triphenylphosphine oxide, and a filler, the triphenylphosphine oxide being included in the curable resin composition in an amount of 1.0% by mass or more.

<2> A curable resin composition, comprising a curable resin component, triphenylphosphine oxide, and a filler, the triphenylphosphine oxide being included in the curable resin composition in an amount of less than 0.3% by mass.

<3> A curable resin composition, comprising a curable resin component, triphenylphosphine oxide, and a filler, the filler including cristobalite.

<4> The curable resin composition according to any one of <1> to <3>, wherein the curable resin component includes an epoxy resin and a curing agent.

<5> The curable resin composition according to any one of <1> to <4>, which is a sealing material for an electronic component device.

<6> The curable resin composition according to any one of <1> to <5>, which is a sealing material for producing at least one package of an electronic component device that includes two or more packages.

<7> An electronic component device, comprising a package that includes a cured product of the curable resin composition according to any one of <1> to <6>.

<8> The electronic component device according to <7>, comprising a first package and a second package, the first package including a cured product of the curable resin composition according to any one of <1> to <6>.

<9> A method of producing an electronic component device, comprising bonding together a first package and a second package, the first package including a cured product of the curable resin composition according to any one of <1> to <6>,

the bonding being carried out such that a state of warping of the first package is in accordance with a state of warping of the second package.

Effects of the Invention

[0008] According to the invention, a cured resin composition that can regulate the warping of a package in a suitable manner, and an electronic component device and a production method thereof, in which the curable resin composition is used, are provided.

DETAILED DESCRIPTION OF THE INVENTION

[0009] Embodiments for carrying out the present invention will now be described in detail. However, the invention is in no way limited to the following embodiments. In the following embodiments, constituent elements (including element steps and the like) of the embodiments are not essential, unless otherwise specified. Likewise, numerical values and ranges thereof are not intended to restrict the invention.

[0010] In the present disclosure, the definition of the term "step" includes not only an independent step which is distinguishable from another step, but also a step which is not clearly distinguishable from another step, as long as the purpose of the step is achieved.

In the present disclosure, any numerical range described using the expression "to" represents a range in which numerical values described before and after the "to" are included in the range as a minimum value and a maximum value, respectively.

In a numerical range described in stages, in the present disclosure, an upper limit value or a lower limit value described in one numerical range may be replaced with an upper limit value or a lower limit value in another numerical range described in stages. Further, in a numerical range described in the present disclosure, the upper limit value or the lower limit value in the numerical range may be replaced with a value shown in the Examples.

In the present disclosure, each component may include plural kinds of substances corresponding to the component. In a case in which plural kinds of substances corresponding to each component are present in a composition, the content ratio or content of each component refers to the total content ratio or content of the plural kinds of substances present in the composition, unless otherwise specified.

In the present disclosure, particles corresponding to each component may include plural kinds of particles. In a case in which plural kinds of particles corresponding to each component are present in a composition, the particle size of each component refers to the value of the particle size of a mixture of the plural kinds of particles present in the composition, unless otherwise specified.

[0011] <Curable resin composition (first embodiment)>

The curable resin composition of the first embodiment includes a curable resin component, triphenylphosphine oxide, and a filler, and the triphenylphosphine oxide is included in the curable resin composition in an amount of 0.3% by mass or more.

[0012] The research made by the inventors has proved that a package that is sealed with a curable resin composition, which includes triphenylphosphine oxide in an amount of 0.3% by mass or more, has a property of causing smile-type (convex downward) warping at high

temperature during a bonding process (for example, 230°C or more). The reason for this has not been exactly clear, but it is presumed to be because the triphenylphosphine oxide behaves like a plasticizer in a cured product of the cured resin composition in the package, and suppresses expansion of the cured product upon heating during the bonding process is suppressed.

[0013] When a curable resin composition that causes smile-type warping is used as a sealing material for one of the packages, for example, in a PoP-type electronic component device in which the other package to be bonded together has a property of causing smile-type warping during a bonding process, it is expected that a state of warping of the packages can be adjusted and favorable bonding can be achieved.

[0014] The content of triphenylphosphine oxide in the curable resin composition is not particularly limited as long as it is 0.3% by mass or more of the total curable resin composition, and may be adjusted depending on a desired state of warping of a package to be produced by using the curable resin composition, contents of other components in the curable resin composition, and the like.

From the viewpoint of increasing a degree of smile-type warping of the package, the content of triphenylphosphine oxide in the curable resin composition is preferably 0.5% by mass or more, more preferably 1.0% by mass or more, further preferably 1.5% by mass or more.

From the viewpoint of the balance with the other components in the curable resin composition, the content of triphenylphosphine oxide in the curable resin composition is preferably 6.0% by mass or less, more preferably 3.0% by mass or less, further preferably 2.0% by mass or less, yet further preferably 1.0% by mass or less.

[0015] The curable resin composition may be in a solid state or in a liquid state. Examples of the configuration of the curable resin composition when it is in a solid state include a powder or a tablet. From the viewpoint of ease of handling, the curable resin composition is preferably in a solid state during using, more preferably in a state of a powder.

[0016] The curable resin composition is preferably a sealing material used for at least one of two or more packages in an electronic component device having two or more packages; more preferably a sealing material used for a package that is disposed above the other package (i.e., disposed at a side of the other package opposite to a substrate on which the electronic component device is disposed).

[0017] (Curable resin component)

The type of the curable resin component included in the curable resin composition is not particularly limited. From the viewpoint of a balance of the properties of a sealing

material, the curable resin component is preferably a combination of an epoxy resin and a curing agent.

[0018] (Epoxy resin)

The type of the epoxy resin is not particularly limited, and can be selected in view of the desired properties of the curable resin composition.

Specific examples of the epoxy resin include novolac-type epoxy resin (such as a phenol novolac-type epoxy resin or an ortho-cresol novolac-type epoxy resin) which is obtained by epoxidizing a novolac resin obtained by condensation or co-condensation of at least one phenolic compound selected from the group consisting of phenol compounds such as phenol, cresol, xylenol, resorcinol, catechol, bisphenol A and bisphenol F, and naphthol compounds such as α-naphthol, β-naphthol and dihydroxynaphthalene, with an aliphatic aldehyde compound such as formaldehyde, acetaldehyde or propionaldehyde, in the presence of an acidic catalyst; triphenylmethane-type epoxy resin which is obtained by epoxidizing a triphenylmethane-type phenol resin obtained by condensation or co-condensation of the above-described phenolic compound with an aromatic aldehyde compound such as benzaldehyde or salicyl aldehyde in the presence of an acidic catalyst; copolymerized epoxy resins which is obtained by epoxidizing a novolac resin obtained by co-condensation of any of the above-described phenol compound and the naphthol compound with an aldehyde compound in the presence of an acidic catalyst; diphenylmethane-type epoxy resin which is a diglycidyl ether of bisphenol A, bisphenol F or the like; biphenyl-type epoxy resin which is a diglycidyl ether of an alkyl-substituted or unsubstituted biphenol; stilbene-type epoxy resin which is a diglycidyl ether of a stilbene-type phenol compound; sulfur atom-containing epoxy resin which is a diglycidyl ether of bisphenol S or the like; epoxy resin which is a glycidyl ether of an alcohol such as butanediol, polyethylene glycol or polypropylene glycol; glycidyl ester-type epoxy resin which is a glycidyl ester of a polyvalent carboxylic acid compound such as phthalic acid, isophthalic acid or tetrahydrophthalic acid; glycidyl amine-type epoxy resin which is obtained by substituting an active hydrogen bound to a nitrogen atom of aniline, diaminodiphenylmethane, isocyanuric acid or the like, with a glycidyl group; dicyclopentadiene-type epoxy resin which is obtained by epoxidizing a co-condensed resin of dicyclopentadiene with a phenol compound; alicyclic-type epoxy resin which is obtained by epoxidizing an olefin bond in the molecule, such as vinylcyclohexene diepoxide, 3,4-epoxycyclohexylmethyl-3,4-epoxycyclohexane carboxylate or 2-(3,4-epoxy)cyclohexyl-5,5-spiro(3,4-epoxy)cyclohexane-m-dioxane; paraxylylene-modified epoxy resin which is a glycidyl ether of a paraxylylene-modified phenol resin; metaxylylene-modified epoxy resin which is a glycidyl ether of a metaxylylene-modified

phenol resin; terpene-modified epoxy resin which is a glycidyl ether of a terpene-modified phenol resin; dicyclopentadiene-modified epoxy resin which is a glycidyl ether of a dicyclopentadiene-modified phenol resin; cyclopentadiene-modified epoxy resin which is a glycidyl ether of a cyclopentadiene-modified phenol resin; polycyclic aromatic ring-modified epoxy resin which is a glycidyl ether of a polycyclic aromatic ring-modified phenol resin; naphthalene-type epoxy resin which is a glycidyl ether of a naphthalene ring-containing phenol resin; halogenated phenol novolac-type epoxy resin; hydroquinone-type epoxy resin; trimethylolpropane-type epoxy resin; linear aliphatic epoxy resin which is obtained by oxidizing an olefin bond with a peracid such as peracetic acid; and aralkyl-type epoxy resin which is obtained by epoxidizing an aralkyl-type phenol resin such as a phenol aralkyl resin or a naphthol aralkyl resin. These epoxy resins may be used singly, or in combination of two or more kinds thereof.

[0019] The epoxy equivalent (molecular weight/ number of epoxy groups) of the epoxy resin is not particularly limited. From the viewpoint of a balance in the properties such as moldability, reflow resistance and electrical reliability, the epoxy equivalent of the epoxy resin is preferably from 100 g/eq to 1,000 g/eq, and more preferably from 150 g/eq to 500 g/eq.

[0020] The epoxy equivalent of the epoxy resin is defined as a value measured by a method in accordance with JIS K 7236: 2009.

[0021] In a case in which the epoxy resin is a solid state, the softening point or the melting point thereof is not particularly limited. From the viewpoint of ease of handling curing the preparation of the curable resin composition, the softening point or the melting point of the epoxy resin is preferably from 50°C to 130°C.

[0022] The melting point of the epoxy resin is defined as a value measured by differential scanning calorimetry (DSC), and the softening point of the epoxy resin is defined as a value measured by a method in accordance with JIS K 7234: 1986 (ring-and-ball method).

[0023] (Curing agent)

The type of the curing agent is not particularly limited, and can be selected in view of the desired properties of the curable resin composition and the like. When the resin to be combined with the curing agent is an epoxy resin, examples of the curing agent include phenol curing agent, amine curing agent, acid anhydride curing agent, polymercaptan curing agent, polyaminoamide curing agent, isocyanate curing agent, and block isocyanate curing agent. From the viewpoint of heat resistance, the curing agent is preferably a compound having phenolic hydroxyl groups (phenol curing agent).

[0024] Specific examples of the phenol curing agent include polyhydric phenol compound

such as resorcinol, catechol, bisphenol A, bisphenol F and a substituted or unsubstituted biphenol; novolac-type phenol resin obtained by condensation or co-condensation of at least one phenolic compound selected from the phenol compounds such as phenol, cresol, xylenol, resorcinol, catechol, bisphenol A, bisphenol F, phenyl phenol and amino phenol, and the naphthol compounds such as α-naphthol, β-naphthol and dihydroxynaphthalene, with an aldehyde compound such as formaldehyde, acetaldehyde, propionaldehyde, benzaldehyde, or salicyl aldehyde in the presence of an acidic catalyst; aralkyl-type phenol resin such as a phenol aralkyl resin or a naphthol aralkyl resin, which is synthesized from the above-described phenolic compound and dimethoxyparaxylene, bis(methoxymethyl)biphenyl or the like; phenol resin modified with paraxylylene or metaxylylene; melamine-modified phenol resin; terpene-modified phenol resin; dicyclopentadiene-type phenol resin and a dicyclopentadiene-type naphthol resin each synthesized by the copolymerization of the above-described phenolic compound and dicyclopentadiene; cyclopentadiene-modified phenol resin; polycyclic aromatic ring-modified phenol resin; biphenyl-type phenol resin; triphenylmethane-type phenol resin obtained by condensation or co-condensation of the above-described phenolic compound with an aromatic aldehyde compound such as benzaldehyde or salicyl aldehyde in the presence of an acidic catalyst; and phenol resin obtained by copolymerization of two or more kinds of the above-mentioned resins. These phenol curing agents may be used singly, or in combination of two or more kinds thereof.

[0025] The functional group equivalent of the curing agent (hydroxy group equivalent in the case of phenol curing agent) is not particularly limited. From the viewpoint of a balance in the properties such as moldability, reflow resistance and electrical reliability, the functional group equivalent of the curing agent is preferably from 70 g/eq to 1,000g/eq, and more preferably from 80 g/eq to 500 g/eq.

[0026] The functional group equivalent of the curing agent (hydroxy group equivalent in the case of phenol curing agent) is defined as a value measured by a method in accordance with JIS K 0070: 1992.

[0027] In a case where the curing agent is in a solid state, the softening point or the melting point thereof is not particularly limited. From the viewpoint of ease of handling in the preparation of the curable resin composition, the softening point or the melting point of the curing agent is preferably from 50°C to 130°C.

[0028] The melting point or the softening point of the curing agent is defined as a value measured in the same manner as the melting point or the softening point of the epoxy resin.

[0029] The blending ratio of the epoxy resin and the curing agent is not particularly limited. From the viewpoint of reducing the unreacted amount of each of the components, the ratio of

the number of functional groups in the curing agent relative to the number of epoxy groups in the epoxy resin (namely, the number of epoxy groups in the epoxy resin/ the number of functional groups in the curing agent) is preferably adjusted within a range of from 0.5 to 2.0, more preferably within a range of from 0.6 to 1.3, and still more preferably within a range of from 0.8 to 1.2.

[0030] (Filler)

The type of the filler is not particularly limited. Specific examples of the filler include inorganic materials such as silica (fused silica, crystalline silica and the like), glass, alumina, calcium carbonate, zirconium silicate, calcium silicate, silicon nitride, aluminum nitride, boron nitride, beryllia, zirconia, zircon, fosterite, steatite, spinel, mullite, titania, talc, clay and mica. A filler having a flame-retardant effect may also be used. Examples of the filler having a flame-retardant effect include aluminum hydroxide, magnesium hydroxide, a composite metal hydroxide such as a composite hydroxide of magnesium and zinc, and zinc borate.

[0031] Among these fillers, silica is preferred from the viewpoint of reducing a linear expansion coefficient, and alumina is preferred from the viewpoint of increasing thermal conductivity. The filler may be used singly, or in combination of two or more kinds thereof. Examples of the configuration of the filler include a powder, a bead obtained by spheronizing the powder, a fiber, and the like.

[0032] The content of the filler in the curable resin composition is not particularly limited. From the viewpoint of improving the flowability and strength, the content of the filler is preferably from 30% by volume to 90% by volume, more preferably from 35% by volume to 80% by volume, further preferably from 40% by volume to 70% by volume, with respect to the total curable resin composition. When the content of the filler is 30% by volume or more with respect to the total curable resin composition, the properties such as thermal expansion coefficient, thermal conductivity and elastic modulus of a cured product obtained from the curable resin composition tend to be further improved. When the content of the filler is 90% by volume or less with respect to the total curable resin composition, an increase in the viscosity of the curable resin composition tends to be suppressed, and the flowability and moldability of the same tend to be improved.

[0033] In a case in which the filler is in the form of particles, the average particle size of the particles is not particularly limited. For example, the volume average particle size of the filler is preferably from 0.2 μm to 20 μm, and more preferably from 0.5 μm to 15 μm. When the volume average particle size of the filler is from 0.2 μm or more, an increase in the viscosity of the curable resin composition tends to be further suppressed. When the volume

average particle size of the filler is 20 μm or less, filling properties of the filler into a narrow gap tends to be further improved. The volume average particle size of the filler can be determined as a volume average particle size (D50) measured with a laser scattering diffraction particle size distribution analyzer, which is a particle size at which the accumulation by volume from the smaller diameter side becomes 50%.

[0034] (Curing accelerator)

The curable resin composition may include a curing accelerator. The type of the curing accelerator is not particularly limited, and may be selected depending on the type of the curable resin, the desired properties of the curable resin composition, and the like.

Examples of the curing accelerator include diazabicycloalkenes such as 1,5-diazabicyclo[4.3.0]nonene-5 (DBN) and 1,8-diazabicyclo[5.4.0]undecene-7 (DBU); cyclic amidine compounds such as 2-methylimidazole, 2-phenylimidazole, 2-phenyl-4-methylimidazole and 2-heptadecylimidazole; derivatives of the cyclic amidine compounds; phenol novolac salts of the cyclic amidine compounds and derivatives thereof; compounds having intramolecular polarization, obtained by adding, to the above-mentioned compounds, a compound containing a π bond, such as maleic anhydride, a quinone compound such as 1,4-benzoquinone, 2,5-toluquinone, 1,4-naphthoquinone, 2,3-dimethylbenzoquinone, 2,6-dimethylbenzoquinone, 2,3-dimethoxy-5-methyl-1,4-benzoquinone, 2,3-dimethoxy-1,4-benzoquinone or phenyl-1,4-benzoquinone, or diazophenylmethane; cyclic amidinium compounds such as tetraphenyl boric acid salts of DBU, tetraphenyl boric acie salts of DBN, tetraphenyl boric acid salts of 2-ethyl-4-methylimidazole, and tetraphenyl boric acid salts of N-methylmorpholine; tertiary amine compounds such as pyridine, triethylamine, triethylenediamine, benzyldimethylamine, triethanolamine, dimethylaminoethanol, and tris(dimethylaminomethyl) phenol; derivatives of the above-mentioned tertiary amine compounds; ammonium salt compounds such as tetra-n-butylammonium acetate, tetra-n-butylammonium phosphate, tetraethylammonium acetate, tetra-n-hexylammonium benzoate, and tetrapropylammonium hydroxide; tertiary phosphines such as triphenylphosphine, diphenyl(p-tolyl)phosphine, tris(alkylphenyl)phosphines, tris(alkoxyphenyl)phosphines, tris(alkyl-alkoxyphenyl)phosphines, tris(dialkylphenyl)phosphines, tris(trialkylphenyl)phosphines, tris(tetraalkylphenyl)phosphines, tris(dialkoxyphenyl)phosphines, tris(trialkoxyphenyl)phosphines, tris(tetraalkoxyphenyl)phosphines, trialkylphosphines, dialkylarylphosphines, and alkyldiarylphosphines; phosphine compounds such as complexes of the tertiary phosphines and organic borons; compounds having intramolecular polarization, which are obtained by

adding, to the above-mentioned tertiary phosphines or the phosphine compounds, a compound containing a π-bond such as maleic anhydride, a quinone compound such as 1,4-benzoquinone, 2,5-toluquinone, 1,4-naphthoquinone, 2,3-dimethylbenzoquinone, 2,6-dimethylbenzoquinone, 2,3-dimethoxy-5-methyl-1,4-benzoquinone, 2,3-dimethoxy-1,4-benzoquinone or phenyl-1,4-benzoquinone, or diazophenylmethane; compounds having intramolecular polarization, which are obtained by a process including allowing the above-mentioned tertiary phosphines or the phosphine compounds to react with a halogenated phenol compound such as 4-bromophenol, 3-bromophenol, 2-bromophenol, 4-chlorophenol, 3-chlorophenol, 2-chlorophenol, 4-iodophenol, 3-iodophenol, 2-iodophenol, 4-bromo-2-methylphenol, 4-bromo-3-methylphenol, 4-bromo-2,6-dimethylphenol, 4-bromo-3,5-dimethylphenol, 4-bromo-2,6-di-tert-butylphenol, 4-chloro-1-naphthol, 1-bromo-2-naphthol, 6-bromo-2-naphthol, or 4-bromo-4'-hydroxybiphenyl, and dehydrohalogenation of the reactant; tetra-substituted phosphoniums and tetra-substituted borates, for example, tetra-substituted phosphoniums such as tetraphenylphosphonium, and tetra-substituted borates such as tetra-p-tolylborate having no phenyl group bound to a boron atom; and salts of tetraphenylphosphonium and phenol compounds.

[0035] In a case in which the curable resin composition includes a curing accelerator, the amount of the curing accelerator is preferably from 0.1 parts by mass to 30 parts by mass, and more preferably from 1 part by mass to 15 parts by mass, with respect to 100 parts by mass of the curable resin component.

[0036] (Coupling Agent)

The curable resin composition may include a coupling agent. Examples of the coupling agent include known coupling agents, for example: silane-based compounds such as epoxysilane, mercaptosilane, aminosilane, alkylsilanes, ureidosilane and vinylsilane; titanium-based compounds; aluminum chelate compounds; and aluminum/zirconium compounds.

[0035] In a case in which the curable resin composition includes a coupling agent, the amount of the coupling agent is preferably from 0.05 parts by mass to 5 parts by mass, and more preferably from 0.1 parts by mass to 2.5 parts by mass, with respect to 100 parts by mass of the inorganic filler. When the amount of the coupling agent is 0.05 parts by mass or more with respect to 100 parts by mass of the inorganic filler, adhesion with respect to a frame tends to be further improved. When the amount of the coupling agent is 5 parts by mass or less with respect to 100 parts by mass of the inorganic filler, the moldability of a package tends to be further improved.

[0036] [Other additives]

The curable resin composition may include various additives, such as a coupling agent, a mold release agent and a colorant. The curable resin composition may include a known additive other than these additives, as necessary.

[0037] (Coupling agent)

The curable resin composition may include a coupling agent in order to improve the adhesion between the resin component and the filler. Examples of the coupling agent include silane compounds such as epoxysilane, mercaptosilane, aminosilane, alkylsilane, ureidosilane and vinylsilane; titanium compounds; aluminum chelate compounds; and aluminium/zirconium compounds. Among these, silane compounds are preferred. The coupling agent may be used singly, or in combination of two or more kinds thereof.

[0038] In a case where the curable resin composition includes a coupling agent, the amount thereof is preferably from 0.05 parts by mass to 5 parts by mass, more preferably from 0.1 parts by mass to 2.5 parts by mass, with respect to 100 parts by mass of the total filler.

[0039] (Mold release agent)

The curable resin composition may include a mold release agent, from the viewpoint of improving mold release properties during a molding process. The mold release agent is not particularly limited, and any of the known materials may be used. Specific examples of the mold release agent include higher fatty acids such as carnauba wax, montanic acid and stearic acid; ester-based waxes such as higher fatty acid metal salts and montanic acid esters; and polyolefin-based waxes such as oxidized polyethylene and non-oxidized polyethylene. The mold release agent may be used singly, or in combination of two or more kinds thereof.

[0040] In a case in which the curable resin composition contains a mold release agent, the amount of the mold release agent is preferably from 0.01 parts by mass to 10 parts by mass, and more preferably from 0.1 parts by mass to 5 parts by mass, with respect to 100 parts by mass of the resin component.

[0041] (Colorant)

The curable resin composition may include a colorant. Examples of the colorant include known colorants such as carbon blacks, organic dyes, organic pigments, titanium oxide, minium and Bengala. The content of the colorant can be selected as appropriate depending on the purpose or the like. The colorant may be used singly, or in combination of two or more kinds thereof.

[0042] In a case where the curable resin composition includes a colorant, the amount thereof is preferably from 0.01 parts by mass to 10 parts by mass, more preferably from 0.1 parts by mass to 5 parts by mass, with respect to 100 parts by mass of the total curable resin component.

[0043] (Applications of curable resin composition)

The curable resin composition may be used for various packaging methods, as a sealing material for an electronic component device. In an embodiment, the curable resin composition is used as a sealing material for producing at least one package included in an electronic component device that includes two or more packages. By using the curable resin composition as a sealing material for one of the two or more packages, it is possible to adjust a state of the warping of the same in accordance with a state of the warping of the other package, thereby achieving favorable bonding between them.

[0044] Examples of the method of producing a package using the curable resin composition include compression molding, transfer molding and injection molding, and the curable resin composition is applicable for any of these methods.

[0045] (Method of preparing curable resin composition)

The method of preparing the curable resin composition is not particularly limited. Examples of general methods include a method in which the components of predetermined amounts are sufficiently mixed with a mixer or the like, melted and kneaded with a mixing roll or an extruder, and cooled and pulverized; more specifically, a method in which the components as described above of predetermined amounts are uniformly mixed, kneaded with a kneader, a roll or an extruder which is preliminarily heated at 70 °C to 140 °C, and cooled and pulverized.

[0046] <Electronic component device>

The electronic component device of the disclosure includes a package including a curable product of the curable resin composition as described above.

[0047] The electronic component device may have a configuration having a first package, which includes a curable product of the curable resin composition, and a second package (for example, a PoP-type electronic component device). In that case, the positional relationship of the first and second packages is not particularly limited, but the first package is preferably positioned over the second package (at a side of the second package opposite to a substrate on which the electronic component device is disposed).

[0048] Examples of the method of producing a package using the curable resin composition include compression molding, transfer molding and injection molding, and the curable resin composition is applicable for any of these methods.

[0049] <Curable resin composition (second embodiment)>

The curable resin composition of the second embodiment includes a curable resin component, triphenylphosphine oxide, and a filler, and the triphenylphosphine oxide is included in the curable resin composition in an amount of less than 0.3% by mass.

[0050] The lower limit of the amount of triphenylphosphine oxide is not particularly limited, but is preferably 0.01% by mass or more of the curable resin composition, for example.

[0051] The research made by the inventors has proved that a package that is sealed with a curable resin composition, which includes triphenylphosphine oxide in an amount of less than 0.3% by mass, has a property of causing cry-type (convex upward) warping at high temperature during a bonding process (for example, 230°C or more).

[0052] When a curable resin composition that causes cry-type warping is used as a sealing material for one of the packages, for example, in a PoP-type electronic component device in which the other package to be bonded together has a property of causing cry-type warping in a bonding process, it is expected that a state of warping of the packages can be adjusted and favorable bonding can be achieved.

[0053] The content of triphenylphosphine oxide in the curable resin composition is not particularly limited as long as it is less than 0.3% by mass of the total curable resin composition, and may be adjusted depending on a desired state of warping of a package to be produced by using the curable resin composition, contents of other components in the curable resin composition, and the like.

From the viewpoint of increasing a degree of cry-type warping of the package, the content of triphenylphosphine oxide in the curable resin composition is preferably 0.2% by mass or less, more preferably 0.1% by mass or less.

[0054] The details and preferred embodiments of the curable resin composition of the second embodiment are the same as the details and preferred embodiments of the curable resin composition of the first embodiment, except that the amount of triphenylphosphine oxide is less than 0.3% by mass.

[0055] <Curable resin composition (third embodiment)>

The curable resin composition of the third embodiment includes a curable resin component, triphenylphosphine oxide, and a filler, and the filler includes cristobalite.

[0056] The research made by the inventors has proved that a package that is sealed with a curable resin composition, which includes cristobalite in addition to triphenylphosphine oxide, has a property of causing cry-type warping of the package. The reason for this is not exactly clear, but it is presumed to be that cristobalite has a property of causing phase transition and increasing the coefficient of expansion at high temperature (230°C to 240°C), whereby the effect of triphenylphosphine oxide is cancelled.

[0057] The content of cristobalite in the curable resin composition is not particularly limited, and may be adjusted depending on a desired state of warping of a package to be produced by using the curable resin composition, contents of other components in the curable resin

composition, and the like.

From the viewpoint of sufficiently achieving the effect of regulating the warping of the package, the content of cristobalite is preferably 2% by mass or more, more preferably 4% by mass or more, further preferably 6% by mass or more, of the total curable resin composition.

[0058] The proportion of cristobalite to the filler is not particularly limited. From the viewpoint of a balance of the properties of the curable resin composition, the proportion of cristobalite to the total filler is preferably 2% by mass or more.

[0059] From the viewpoint of avoiding soft errors in a case in which the curable resin composition is used for memory packages, it is preferred to use cristobalite having an alpha dose of 5 ppb or less. By combining cristobalite having an alpha dose of 5 ppb or less with a filler having a low degree of alpha dose, occurrence of soft errors of an electronic component device due to emission of alpha-ray can be effectively avoided. The alpha dose of cristobalite can be measured with a Geiger counter, for example.

[0060] The content of triphenylphosphine oxide in the curable resin composition is not particularly limited, and may be adjusted depending on a desired state of warping of a package to be produced by using the curable resin composition, contents of other components in the curable resin composition, and the like.

From the viewpoint of sufficiently achieving a flame-retardant effect, the content of triphenylphosphine oxide is preferably 0.2% by mass or more, more preferably 0.3% by mass or more, further preferably 0.5% by mass or more, of the total curable resin composition.

From the viewpoint of the balance with respect to the other components, the content of triphenylphosphine oxide is preferably 3.0% by mass or less, more preferably 2.0% by mass or less, further preferably 1.0% by mass or less, of the total curable resin composition.

[0061] The details and preferred embodiments of the curable resin composition of the third embodiment are the same as the details and preferred embodiments of the curable resin composition of the first embodiment, except that the filler includes cristobalite.

[0062] <Method of producing electronic component device>

The method of producing an electronic component device of the disclosure includes bonding together a first package and a second package, the first package including a cured product of the curable resin composition as described above, the bonding being carried out such that a state of warping of the first package is in accordance with a state of warping of the second package.

[0063] By carrying out the bonding of the first and second packages such that a state of warping of the first package is in accordance with a state of warping of the second package,

favorable bonding between the packages can be achieved.

[0064] Examples of the case in which a state of warping of the first package is in accordance with a state of warping of the second package include a case in which both of the first and second packages cause either smile-type warping or cry-type warping under the temperature conditions for bonding, and the curvature of the warping of the packages are similar to each other.

[0065] By adjusting the amount of triphenylphosphine oxide included in the curable resin composition, which is used for the preparation of the first package, it is possible to adjust a state of warping of the first package to be in accordance with a state of warping of the second package, during the bonding process.

Accordingly, the method may include a process of regulating the amount of triphenylphosphine oxide included in the curable resin composition, which is used for the preparation of the first package, in accordance with a state of warping of the second package.

[0066] The method of bonding the first package to the second package is not particularly limited. For example, the bonding may be carried out by a method of heating the packages to a temperature at which a bonding material disposed between the packages, such as solder balls, is melted.

[0067] In the method, the positional relationship of the first package and the second package is not particularly limited. Preferably, the first package is disposed over the second package (at a side of the second package opposite to a substrate on which the electronic component device is disposed).

EXAMPLES

[0068] In the following, the embodiments as described above are described in specific detail with reference to the Examples. However, the scope of the embodiments are not limited to the Examples.

[0069] (Preparation of curable resin composition)

The following components were mixed by the amounts described in Table 1 (mass by parts), and curable resin compositions of the Examples and the Comparative Examples were prepared.

[0070] Epoxy resin 1: biphenyl-type epoxy resin, epoxy equivalent 192 g/eq (Mitsubishi Chemical Corporation, YX-4000)

Epoxy resin 2: bipheneylene aralkyl-type epoxy resin, epoxy equivalent 277 g/eq (Nippon Kayaku Co., Ltd., NC-3000)

[0071] Curing agent 1: biphenyl-type phenol resin, hydroxy equivalent 202 g/eq (Meiwa

Plastic Industries, MEHC-7851-SS)

Curing agent 2: triphenylmethane-type phenol resin, hydroxy equivalent 103 g/eq (Meiwa Plastic Industries, MEH-7500-3S)

[0072] Curing accelerator 1: adduct of triphenylphosphine and 1,4-benzoquinone

Curing accelerator 2: adduct of tri-n-butylphosphine and 1,4-benzoquinone

Coupling agent 1: N-phenyl-3-aminopropyltrimethoxysilane (Shin-Etsu Chemical Co., Ltd., KBM-573)

Coupling agent 2: methyltrimethoxysilane (Shin-Etsu Chemical Co., Ltd., KBM-13)

Mold release agent 1: montanic acid ester wax (Clariant AG, HW-E)

Mold release agent 2: polyethylene wax

Colorant: carbon black (Mitsubishi Chemical Corporation, MA600)

[0073] Ion trapping agent: magnesium/aluminum hydroxide/carbonate/hydrate (Sakai Chemical Industry Co., Ltd., STABIACE HT-P)

Silicone compound: polysiloxane (DuPont Toray Specialty Materials K.K., AY42-119)

Triphenylphosphine oxide (TPPO)

Filler 1: fused silica (volume average particle size: 20 μm)

Filler 2: cristobalite (volume average particle size: 11 μm)

[0074] (Evaluation of state of warping)

A package for evaluation (15 mm x 15 mm, thickness of sealing: 350 mm, total thickness: 440 mm), with a chip (9 mm x 9 mm, thickness: 150 μm) mounted thereon, was prepared using the curable resin composition.

After carrying out post-curing at 175 °C for 5 hours, the package was placed in a heater, and the temperature inside the heater was increased from 30 °C to 260 °C at a rate of 10 °C /25 sec, and then decreased from 260 °C to 30 °C at a rate of 10 °C /25 sec. A state of warping of the package at 260 °C and a maximum height of the warping from the ground surface (μm) were evaluated and shown in Table 1. In Table 1, the maximum height of the smile-type warping is described as a negative value, and the maximum height of the cry-type warping is described as a positive value.

Table 1

	Example 1-1	Example 1-2	Example 1-3	Example 1-4	Example 1-5	Example 2-1	Example 2-2	Example 3-1	Example 3-2	Example 3-3
Epoxy resin 1	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Epoxy resin 2	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Curing agent 1	41.9	41.9	41.9	41.9	41.9	41.9	41.9	41.9	41.9	41.9
Curing agent 2	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0
Curing accelerator 1	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Curing accelerator 2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Coupling agent 1	6.8	6.8	6.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Coupling agent 2	4.5	4.5	4.5	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Mold release agent 1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mold release agent 2	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Colorant	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Ion trapping agent	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Silicone compound	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
TPPO	10.0	20.0	30.0	10.0	5.0	1.0	3.0	10.0	10.0	10.0
Filler 1	1,488	1,555	1,621	1,433	1,399	1,373	1,386	1,375	1,361	1,289
Filler 2 (cristobalite)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	61.0	76.0	152.0
TPPO (% by mass)	0.6	1.1	1.6	0.6	0.3	0.1	0.2	0.6	0.6	0.6
Cristobalite (% by mass)	0	0	0	0	0	0	0	3.7	4.6	9.2
Filler content (% by volume)	78	78	78	78	78	78	78	78	78	78
State of warping	smile	smile	smile	smile	smile	cry	cry	cry	cry	cry
Evalutatio of warping (μm	-51	-110	-146	-28	-3	33	32	27	35	75

[0075] As shown in Table 1, the packages of Examples 1-1 to 1-5, prepared by using a curable resin composition including triphenylphosphine oxide in an amount of 0.3% by mass or more, exhibited smile-type warping when the temperature reached 260 °C.

The packages of Examples 1-2 and 2-2, prepared by using a curable resin composition including triphenylphosphine oxide in an amount of less than 0.3% by mass, exhibited cry-type warping when the temperature reached 260 °C.

The packages of Examples 3-1 to 3-3, prepared by using a curable resin composition including triphenylphosphine oxide and cristobalite, exhibited cry-type warping when the temperature reached 260 °C.

In view of the above, it is proved that a state of warping of a package during a bonding process can be regulated by using the curable resin composition of the disclosure.

[0076] The disclosure of Japanese Patent Application Nos. 2017-194180, 2017-194181 and 2017-194182 is incorporated herein by reference in its entirety.

All publications, patent applications, and technical standards mentioned in the present specification are incorporated herein by reference to the same extent as if each individual publication, patent application, or technical standard was specifically and individually indicated to be incorporated by reference.

CLAIMS

1. A curable resin composition, comprising a curable resin component, triphenylphosphine oxide, and a filler, the triphenylphosphine oxide being included in the curable resin composition in an amount of 1.0% by mass or more.

2. The curable resin composition according to claim 1, wherein the triphenylphosphine oxide is included in the curable resin composition in an amount of 6.0% by mass or less.

3. The curable resin composition according to claim 1, wherein the triphenylphosphine oxide is included in the curable resin composition in an amount of 3.0% by mass or less.

4. The curable resin composition according to any one of claim 1 to claim 3, wherein the curable resin component includes an epoxy resin and a curing agent.

5. The curable resin composition according to any one of claim 1 to claim 4, which is a sealing material for an electronic component device.

6. The curable resin composition according to any one of claim 1 to claim 5, which is a sealing material for producing at least one package of an electronic component device that includes two or more packages.

7. An electronic component device, comprising a package that includes a cured product of the curable resin composition according to any one of claim 1 to claim 6.

8. The electronic component device according to claim 7, comprising a first package and a second package, the first package including a cured product of the curable resin composition according to any one of claim 1 to claim 6.

9. A method of producing an electronic component device, comprising bonding together a first package and a second package, the first package including a cured product of the curable resin composition according to any one of claim 1 to claim 6,

the bonding being carried out such that a state of warping of the first package is in

accordance with a state of warping of the second package.