

DESCRIPTION

TITLE OF THE INVENTION: PHOTSENSITIVE RESIN COMPOSITION,
PHOTSENSITIVE RESIN SHEET, HOLLOW STRUCTURE, CURED MATERIAL,
HOLLOW STRUCTURE PRODUCTION METHOD, ELECTRONIC COMPONENT, AND
ELASTIC WAVE FILTER

TECHNICAL FIELD

[0001]

The present invention relates to a photosensitive resin composition. More specifically, the present invention relates to a photosensitive resin composition suitable for forming an insulating film excellent in wet heat resistance.

BACKGROUND ART

[0002]

The photosensitive resin composition is widely used as an insulating film of a wiring board because it can be finely processed by a photolithography technique. Further, a material obtained by molding a photosensitive resin composition into a sheet shape has been increasingly applied to a roof material for forming a hollow structure of an electronic component by utilizing the feature of the sheet shape. In recent years, a photosensitive resin sheet used for forming a roof of a hollow structure has been required to have pattern-processability for performing fine processing and

pressure resistance to withstand a sealing step. A method of adding an inorganic filler for improve pressure resistance to increase an elastic modulus has been proposed. In particular, a technique proposed in Patent Document 1 in which a glass filler of which a refractive index is matched with that of a photosensitive resin composition is expected to suppress scattering of light using exposure and achieve pattern-processability in addition to improving pressure resistance by adding the filler.

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0003]

Patent Document 1: Japanese Patent Laid-open Publication
No. 2015-118194

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0004]

However, the glass filler described in Patent Document 1, elution of a glass component occurs due to an influence of humidity, and there is a concern that characteristics of an electronic component are deteriorated.

[0005]

Therefore, the present invention provides a

photosensitive resin composition capable of forming an insulating film that is excellent in pattern-processability and pressure resistance and has high reliability by applying a glass filler that does not cause elution of a glass component due to an influence of humidity.

SOLUTIONS TO THE PROBLEMS

[0006]

In order to achieve the objects, the present invention is as follows.

A photosensitive resin composition containing a polymer (A), a glass filler (B), a photopolymerizable compound (C), and a photopolymerization initiator (D),

in which the glass filler (B) contains at least two selected from the group consisting of silicon oxide, aluminum oxide, and boron oxide, and further contains a rare earth oxide.

EFFECTS OF THE INVENTION

[0007]

According to the present invention, an insulating film that is excellent in pattern-processability and pressure resistance and has high reliability can be formed. The photosensitive resin composition of the present invention can be suitable for a substrate required to have a high elastic modulus and a high resolution, or an electronic component having

a hollow structure also required to have pressure resistance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Fig. 1A is a plan schematic view illustrating an aspect in which a convex portion for forming a hollow structure of the present invention.

Fig. 1B is a schematic view illustrating an example of a method for forming a hollow structure using a photosensitive resin sheet of the present invention.

EMBODIMENTS OF THE INVENTION

[0009]

A photosensitive resin composition of the present invention is

a photosensitive resin composition containing a polymer (A), a glass filler (B), a photopolymerizable compound (C), and a photopolymerization initiator (D), in which the glass filler (B) contains at least two selected from the group consisting of silicon oxide, aluminum oxide, and boron oxide, and further contains a rare earth oxide.

[0010]

The photosensitive resin composition of the present invention can form a negative pattern that easily dissolves in a developer before exposure, but becomes insoluble in the

developer after exposure, and can obtain an insulating film having high reliability by performing a heat treatment after forming a pattern.

[0011]

The photosensitive resin composition of the present invention contains the polymer (A). By containing the polymer, a thick film of the photosensitive resin composition is easily formed, and a film thickness is easily adjusted according to the purpose. The main skeleton of the polymer is not particularly limited, but a (meth)acrylic polymer, an epoxy polymer, polyurethane, polybenzoxazine, polyamic acid, polyimide, and the like can be used. Among them, polyamic acid and polyimide are preferably used in terms of ease of imparting heat resistance and alkali solubility, and polyimide is most preferable because a heat treatment temperature after pattern processing can be lowered.

[0012]

It is preferable that the polymer (A) is dissolved in a developer, and in particular, it is preferable that the polymer (A) has alkali solubility. The alkali solubility as used here means that solubility in a 2.38 wt% tetramethylammonium hydroxide (TMAH) aqueous solution is 0.1 g/100 mL or more. By imparting alkali solubility to the polymer (A) that is a main component of the photosensitive resin composition, dissolution of the photosensitive resin composition in an alkali developer

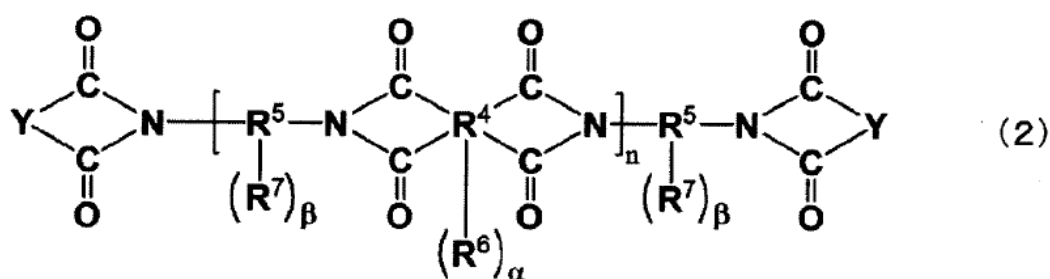
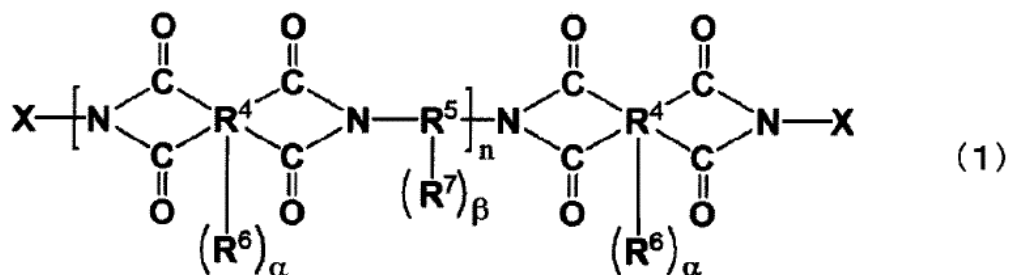
is promoted, and an excellent pattern can be obtained. Examples of a functional group that imparts the alkali solubility to the polymer (A), that is, an alkali-soluble group include a phenolic hydroxyl group, a thiol group, a carboxyl group, a sulfonic acid group, and the like. It is preferable that an alkali-soluble polymer (A-1) has one or both of a phenolic hydroxyl group and a carboxyl group as the alkali-soluble group.

[0013]

As for the alkali-soluble polymer (A-1), an example of polyimide is described below. In a case where polyimide is used as the alkali-soluble polymer (A-1), a composition thereof is not particularly limited as long as it has alkali solubility, but it is preferable to contain one or more kinds of polyimide represented by the following General Formula (1) or (2).

[0014]

[Chem. 1]



[0015]

(In the formula, X represents a monovalent organic group having at least one group selected from the group consisting of a carboxyl group, a phenolic hydroxyl group, a sulfonic acid group, and a thiol group, and Y represents a divalent organic group having at least one group selected from the group consisting of a carboxyl group, a phenolic hydroxyl group, a sulfonic acid group, and a thiol group. In addition, R⁴ represents a 4- to 14-valent organic group, R⁵ represents a 2- to 12-valent organic group, and R⁶ and R⁷ each independently represent at least one alkali-soluble group selected from the group consisting of a carboxyl group, a phenolic hydroxyl group, a sulfonic acid group, and a thiol group. In addition, α and β each independently represent an integer of 0 to 10, and n

represents an integer of 3 to 200.)

X is a monovalent organic group having at least one group selected from the group consisting of a carboxyl group, a phenolic hydroxyl group, a sulfonic acid group, and a thiol group. Among them, a monovalent organic group having a phenolic hydroxyl group or a thiol group is preferable. Y is a divalent organic group having at least one group selected from the group consisting of a carboxyl group, a phenolic hydroxyl group, a sulfonic acid group, and a thiol group. Among them, a divalent organic group having a phenolic hydroxyl group or a thiol group is preferable.

[0016]

n represents the number of repetitions of the structural unit of the polymer. n is in a range of 3 to 200, and is preferably 5 to 100. When n is in the range of 3 to 200, the photosensitive adhesive composition can be used in a thick film, sufficient solubility in the alkali developer can be imparted, and pattern processing can be performed.

[0017]

In General Formulas (1) and (2), R^4 represents a structural component derived from tetracarboxylic dianhydride. In particular, R^4 is preferably an organic group having 5 to 40 carbon atoms and containing an aromatic group or a cycloaliphatic group.

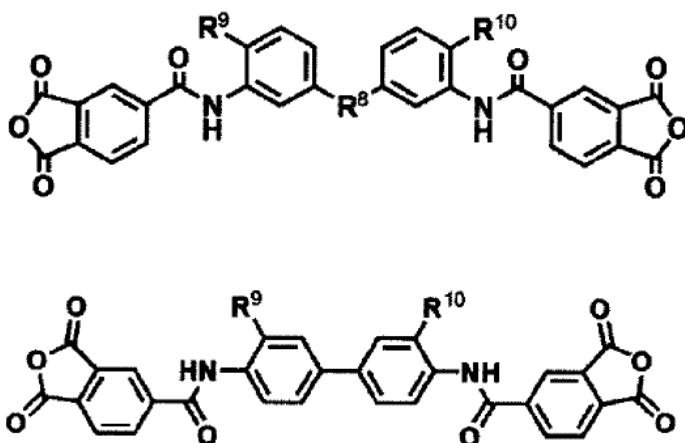
[0018]

Specific examples of the tetracarboxylic dianhydride include aromatic tetracarboxylic dianhydrides such as pyromellitic dianhydride, 3,3',4,4'-biphenyltetracarboxylic dianhydride, 2,3,3',4'-biphenyltetracarboxylic dianhydride, 2,2',3,3'-biphenyltetracarboxylic dianhydride, 3,3',4,4'-benzophenone tetracarboxylic dianhydride, 2,2',3,3'-benzophenone tetracarboxylic dianhydride, 2,2-bis(3,4-dicarboxyphenyl)propane dianhydride, 2,2-bis(2,3-dicarboxyphenyl)propane dianhydride, 1,1-bis(3,4-dicarboxyphenyl)ethane dianhydride, 1,1-bis(2,3-dicarboxyphenyl)ethane dianhydride, bis(3,4-dicarboxyphenyl)methane dianhydride, bis(2,3-dicarboxyphenyl)methane dianhydride, bis(3,4-dicarboxyphenyl)sulfone dianhydride, bis(3,4-dicarboxyphenyl)ether dianhydride, 1,2,5,6-naphthalenetetracarboxylic dianhydride, 9,9-bis(3,4-dicarboxyphenyl)fluorene acid dianhydride, 9,9-bis{4-(3,4-dicarboxyphenoxy)phenyl}fluorene dianhydride, 2,3,6,7-naphthalenetetracarboxylic dianhydride, 2,3,5,6-pyridinetetracarboxylic dianhydride, 3,4,9,10-perylenetetracarboxylic dianhydride, and 2,2-bis(3,4-dicarboxyphenyl)hexafluoropropane dianhydride, aliphatic tetracarboxylic dianhydrides such as butanetetracarboxylic dianhydride and 1,2,3,4-cyclopentanetetracarboxylic dianhydride, acid

dianhydrides with structures shown below, and the like. These are used alone or in combination of two or more thereof.

[0019]

[Chem. 2]



[0020]

Here, R^8 represents an oxygen atom or a group selected from $C(CF_3)_2$, $C(CH_3)_2$, and SO_2 , and each of R^9 and R^{10} represents a group selected from a hydroxyl group and a thiol group.

[0021]

In General Formulas (1) and (2), R^5 represents a structural component derived from diamine and is a 2- to 12-valent organic group. In particular, R^5 is preferably an organic group having 5 to 40 carbon atoms and containing an aromatic group or a cycloaliphatic group.

[0022]

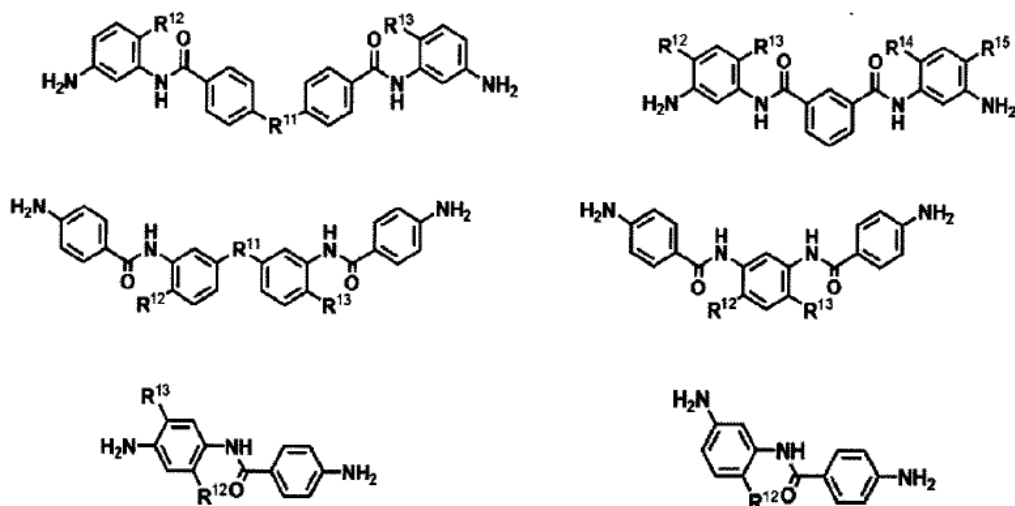
Specific examples of the diamine include hydroxyl-group-containing diamines such as

bis(3-amino-4-hydroxyphenyl)hexafluoropropane,
 bis(3-amino-4-hydroxyphenyl)sulfone,
 bis(3-amino-4-hydroxyphenyl)propane,
 bis(3-amino-4-hydroxyphenyl)methylene,
 bis(3-amino-4-hydroxyphenyl)ether,
 bis(3-amino-4-hydroxy)biphenyl, and
 bis(3-amino-4-hydroxyphenyl)fluorene, thiol group-containing
 diamine such as dimercaptophenylenediamine,
 3,3'-diaminodiphenyl ether, 3,4'-diaminodiphenyl ether,
 4,4'-diaminodiphenyl ether, 3,3'-diaminodiphenyl methane,
 3,4'-diaminodiphenyl methane, 4,4'-diaminodiphenyl methane,
 3,3'-diaminodiphenyl sulfone, 3,4'-diaminodiphenyl sulfone,
 4,4'-diaminodiphenyl sulfone, 3,4'-diaminodiphenyl sulfide,
 4,4'-diaminodiphenyl sulfide, 1,4-bis(4-aminophenoxy)benzene,
 1,3-bis(4-aminophenoxy)benzene,
 1,3-bis(3-aminophenoxy)benzene, benzidine,
 m-phenylenediamine, p-phenylenediamine,
 1,5-naphthalenediamine, 2,6-naphthalenediamine,
 bis(4-aminophenoxyphenyl)sulfone,
 bis(3-aminophenoxyphenyl)sulfone,
 bis(4-aminophenoxy)biphenyl,
 bis{4-(4-aminophenoxy)phenyl}ether,
 2,2'-dimethyl-4,4'-diaminobiphenyl,
 2,2'-diethyl-4,4'-diaminobiphenyl,
 3,3'-dimethyl-4,4'-diaminobiphenyl,

3,3'-diethyl-4,4'-diaminobiphenyl,
 2,2',3,3'-tetramethyl-4,4'-diaminobiphenyl,
 3,3',4,4'-tetramethyl-4,4'-diaminobiphenyl,
 2,2'-di(trifluoromethyl)-4,4'-diaminobiphenyl,
 9,9-bis(4-aminophenyl)fluorene, or compounds such as
 substituted in those aromatic rings with an alkyl group or
 halogen atom, aliphatic cyclohexyldiamine,
 methylenebiscyclohexylamine, diamines with structures shown
 below, and the like. These are used alone or in combination
 of two or more thereof.

[0023]

[Chem. 3]



[0024]

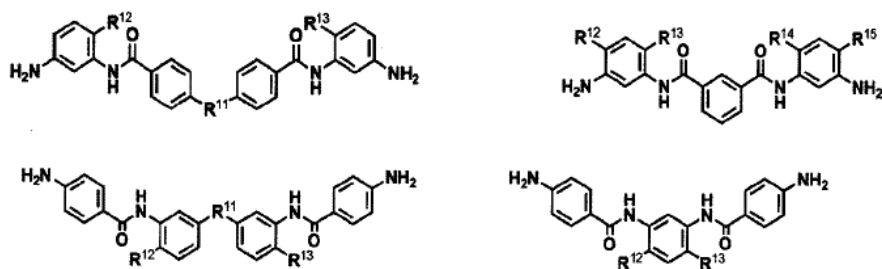
Here, R¹¹ represents an oxygen atom or a group selected from C(CF₃)₂, C(CH₃)₂, and SO₂, and each of R¹² to R¹⁵ represents a group selected from a hydroxyl group and a thiol group.

[0025]

Among them, hydroxyl-group-containing diamines such as bis(3-amino-4-hydroxyphenyl)hexafluoropropane, bis(3-amino-4-hydroxyphenyl)sulfone, bis(3-amino-4-hydroxyphenyl)propane, bis(3-amino-4-hydroxyphenyl)methylene, bis(3-amino-4-hydroxyphenyl)ether, bis(3-amino-4-hydroxy)biphenyl, and bis(3-amino-4-hydroxyphenyl)fluorene, thiol group-containing diamine such as dimercaptophenylenediamine, 3,3'-diaminodiphenyl ether, 3,4'-diaminodiphenyl ether, 4,4'-diaminodiphenyl ether, 3,3'-diaminodiphenylmethane, 3,4'-diaminodiphenyl methane, 4,4'-diaminodiphenyl methane, 3,3'-diaminodiphenyl sulfone, 3,4'-diaminodiphenyl sulfone, 4,4'-diaminodiphenyl sulfone, 3,4'-diaminodiphenyl sulfide, 4,4'-diaminodiphenyl sulfide, m-phenylenediamine, p-phenylenediamine, 1,4-bis(4-aminophenoxy)benzene, 9,9-bis(4-aminophenyl)fluorene, diamines with structures shown below, and the like, are preferable.

[0026]

[Chem. 4]



[0027]

Here, R^{11} represents an oxygen atom or a group selected from $C(CF_3)_2$, $C(CH_3)_2$, and SO_2 , and each of R^{12} to R^{15} represents a group selected from a hydroxyl group and a thiol group.

[0028]

In General Formulas (1) and (2), R^6 and R^7 each independently represent at least one alkali-soluble group selected from the group consisting of a carboxyl group, a phenolic hydroxyl group, a sulfonic acid group, and a thiol group. By adjusting the amounts of the alkali-soluble groups of R^6 and R^7 , a dissolution rate of the polyimide in the aqueous alkali solution is changed, such that a negative photosensitive adhesive composition having an appropriate dissolution rate can be obtained.

[0029]

Furthermore, in order to improve adhesiveness to a substrate, an aliphatic group having a siloxane structure may be copolymerized with R^5 in a range in which heat resistance is not reduced. Specific examples of the diamine component

include those obtained by copolymerizing 1 to 10 mol% of bis(3-aminopropyl)tetramethyldisiloxane, bis(p-amino-phenyl)octamethylpentasiloxane, and the like.

[0030]

In General Formula (1), X is derived from a primary monoamine that is a terminal blocking agent. As the primary monoamine used as a terminal blocking agent, 5-amino-8-mercaptoquinoline, 1-hydroxy-7-aminonaphthalene, 1-hydroxy-6-aminonaphthalene, 1-hydroxy-5-aminonaphthalene, 1-hydroxy-4-aminonaphthalene, 2-hydroxy-7-aminonaphthalene, 2-hydroxy-6-aminonaphthalene, 2-hydroxy-5-aminonaphthalene, 1-carboxy-7-aminonaphthalene, 1-carboxy-6-aminonaphthalene, 1-carboxy-5-aminonaphthalene, 2-carboxy-7-aminonaphthalene, 2-carboxy-6-aminonaphthalene, 2-carboxy-5-aminonaphthalene, 2-aminobenzoic acid, 3-aminobenzoic acid, 4-aminobenzoic acid, 4-aminosalicylic acid, 5-aminosalicylic acid, 6-aminosalicylic acid, 2-aminobenzene sulfonic acid, 3-aminobenzene sulfonic acid, 4-aminobenzene sulfonic acid, 3-amino-4,6-dihydroxypyrimidine, 2-aminophenol, 3-aminophenol, 4-aminophenol, 2-aminothiophenol, 3-aminothiophenol, 4-aminothiophenol, and the like are preferable. These are used alone or in combination of two or more thereof.

[0031]

In addition, in General Formula (2), Y is derived from

a dicarboxylic anhydride that is a terminal blocking agent. As the acid anhydride used as a terminal blocking agent, 4-carboxyphthalic anhydride, 3-hydroxyphthalic anhydride, cis-aconitic anhydride, and the like are preferable. These are used alone or in combination of two or more thereof.

[0032]

The alkali-soluble polyimide used in the present invention may have only the structure represented by General Formula (1) or (2), and may be a mixture with another structure having alkali-solubility. In this case, it is preferable that the alkali-soluble polyimide represented by General Formula (1) or (2) is contained in an amount of 30 wt% or more with respect to the total weight of the alkali-soluble polyimide.

Furthermore, the content is preferably 60 wt% or more. When the content is 30 wt% or more, shrinkage during thermal curing can be suppressed, which is suitable for producing a thick film. The type and amount of polyimide to be mixed are preferably selected in a range in which the heat resistance of the polyimide obtained by the final heat treatment is not impaired.

[0033]

The alkali-soluble polyimide can be synthesized using a known method by substituting a part of diamine with monoamine that is a terminal blocking agent or by substituting tetracarboxylic dianhydride with dicarboxylic anhydride that is a terminal blocking agent. For example, a polyimide

precursor is obtained using methods such as a method of reacting tetracarboxylic dianhydride, a diamine compound, and monoamine at a low temperature, a method of reacting tetracarboxylic dianhydride, dicarboxylic anhydride, and a diamine compound at a low temperature, and a method of obtaining a diester from tetracarboxylic dianhydride and an alcohol and then performing a reaction in the presence of diamine, monoamine, and a condensing agent. Thereafter, polyimide can be synthesized using a method of completely imidizing the resulting polyimide precursor using a known imidization reaction method.

[0034]

In addition, an imidization ratio of the alkali-soluble polyimide can be easily determined, for example, by the following method. Here, the imidization ratio means how many mol% of the polyimide precursor is converted into polyimide in the case of synthesizing polyimide via the polyimide precursor as described above. First, an infrared absorption spectrum of a polymer is measured, and the presence of absorption peaks (near $1,780\text{ cm}^{-1}$ and near $1,377\text{ cm}^{-1}$) of an imide structure derived from polyimide is confirmed. Next, the polymer is subjected to a heat treatment at 350°C for 1 hour, an infrared spectrum is measured again, and then, peak intensities near $1,377\text{ cm}^{-1}$ before the heat treatment and after the heat treatment are compared. Assuming that the imidization ratio of the polymer after the heat treatment is 100%, the imidization ratio

of the polymer before the heat treatment is determined. The imidization ratio of the polymer is preferably 90% or more.

[0035]

The terminal blocking agent introduced into the alkali-soluble polyimide can be detected by the following method. For example, the polyimide into which the terminal blocking agent is introduced is dissolved in an acidic solution and decomposed into an amine component and a carboxylic anhydride component that are constituent units of the polyimide, and then, measurement is performed by gas chromatography (GC) or NMR. Alternatively, the terminal blocking agent can also be detected by directly measuring the polyimide into which the terminal blocking agent is introduced using pyrolysis gas chromatograph (PGC) or an infrared spectrum and a ^{13}C NMR spectrum.

[0036]

A content of the alkali-soluble polymer (A-1) is preferably in a range of 10 to 60 wt% in 100 wt% of solids in the photosensitive resin composition. Within this range, excellent developability and pattern-processability can be obtained. The solid as used here refers to a component that remains on a substrate when a photosensitive resin composition is applied onto a substrate such as a support film and dried to form a layer formed of the photosensitive resin composition, that is, a component excluding a solvent that does not remain

on the substrate.

[0037]

The photosensitive resin composition of the present invention contains the glass filler (B). The glass filler (B) contains at least two selected from the group consisting of silicon oxide, aluminum oxide, and boron oxide, and the glass filler (B) further contains a rare earth oxide. By containing the rare earth oxide, elution of a glass component due to humidity described below can be prevented, and a refractive index can be appropriately adjusted. The rare earth oxide contained in the glass filler (B) may be one kind, or two or more kinds thereof may be used in combination. These silicon oxide, aluminum oxide, boron oxide, and rare earth oxide are contained in the glass filler as a mixture, a solid solution, or a composite oxide, which is effective in the present invention. In the glass filler (B), contents of magnesium oxide, calcium oxide, and zinc oxide in which elution of components occurs due to the influence of humidity are preferably small, and it is more preferable that the glass filler (B) does not contain them. Furthermore, it is more preferable that the glass filler (B) does not contain an alkali metal oxide from the viewpoint of insulation reliability. In addition, the glass filler (B) is preferably yttrium oxide or lanthanoid oxide among rare earth oxides from the viewpoint of ease of mixing with at least two oxides of silicon oxide, aluminum oxide, and boron

oxide, and it is more preferable to use yttrium oxide from the viewpoint of accurately adjusting a refractive index of the glass filler (B).

[0038]

As described above, since the contents of the magnesium oxide, calcium oxide, and zinc oxide are preferably small, the total amount of magnesium ions, calcium ions, and zinc ions detected in an extract obtained by performing an extraction treatment on the glass filler (B) under a saturated water vapor pressure condition at 121°C for 24 hours is preferably 100 ppm (weight basis) or less in the glass filler (B). The measurement can be performed by a method described in Examples described below.

[0039]

In order to set the total amount of magnesium ions, calcium ions, and zinc ions detected in the extract obtained by performing the extraction treatment on the glass filler (B) under the saturated water vapor pressure condition at 121°C for 24 hours to 100 ppm (weight basis) or less in the glass filler (B), and further to obtain the glass filler (B) having a refractive index of 1.55 to 1.75 at 405 nm, it is preferable that the glass filler has the total content of at least two selected from the group consisting of silicon oxide, aluminum oxide, and boron oxide of 65 to 85%, and the total content of rare earth oxides of 15 to 35 wt%, in 100 wt% of the glass filler

(B). More preferably, the glass filler contains 40 to 50 wt% of silicon oxide, 20 to 30 wt% of aluminum oxide, 0 to 10 wt% of boron oxide, and 15 to 35 wt% of a rare earth oxide in 100 wt% of the glass filler (B). The content of the rare earth oxide contained in the glass filler can be measured by a generally known quantitative method for measuring inorganic elements, and can be measured by combining SEM-EDX, TEM-EDX, ICP-MS, fluorescent X-ray analysis, X-ray diffraction, electron beam diffraction, and the like. SEM-EDX refers to scanning electron microscope-energy dispersive X-ray spectroscopy, TEM-EDX refers to transmission electron microscope-energy dispersive X-ray spectroscopy, and ICP-MS refers to inductively coupled plasma mass spectrometry.

[0040]

Glass in the present invention refers to glass having no sharp peak (half-value width of 2° or less) representing a crystal structure of a specific component in powder X-ray diffraction measurement of $2\theta-\theta$.

[0041]

The refractive index of the glass filler (B) is preferably 1.55 to 1.75. The refractive index of the glass filler can be measured by a V block method. In the present invention, the result of measurement at a wavelength of 405 nm is taken as the refractive index. In a case where a difference in refractive index between the glass filler and the organic component in the

photosensitive resin composition is large, reflection or scattering occurs at an interface, such that a resolution is deteriorated. In order to obtain an excellent resolution, an absolute value of the difference between the refractive index of the glass filler (B) and the refractive index of the organic component (excluding solvent) obtained by removing the glass filler (B) from the photosensitive resin composition is preferably 0.05 or less. The refractive index of the organic component (excluding the solvent) in the photosensitive resin composition mainly depends on a refractive index of polymer (A), and in a case where the polymer (A) is polyimide, a refractive index is 1.55 to 1.75. The refractive index of the organic component (excluding the solvent) in the photosensitive resin composition can be determined by preparing only the organic component of the photosensitive resin composition and measuring light having a wavelength of 405 nm at 25°C by an ellipsometry method after the application and drying steps.

[0042]

An average particle diameter of the glass filler (B) is preferably 0.1 to 3.0 μm , and more preferably 0.1 to 2.0 μm . As the average particle diameter is smaller, smoothness of a surface of an insulating film after pattern processing can be more improved. The average particle diameter of the glass filler referred to in the present invention is a value of a 50 vol% particle diameter measured using a particle size

distribution meter (Microtrac particle size analyzer MODEL MT3000) using a laser diffraction scattering method. The measurement is performed by taking about 1 g of a sample and dispersing the sample in purified water for 1 to 3 minutes with ultrasonic waves having a power of 40 W. In a case where the shape of the glass filler is not spherical, the average particle diameter obtained by the laser diffraction scattering method represents a diameter of a volume equivalent shape, but the average particle diameter is preferably in the above range regardless of the shape of the glass filler. Examples of the shape of the glass filler (B) include, but are not limited to, a spherical shape, a needle shape, a fiber shape, an amorphous granular shape, a plate shape, a crushed shape, and the like.

[0043]

The glass filler (B) used in the photosensitive resin composition of the present invention is contained in an amount of preferably 30 to 80 wt%, and more preferably 60 to 80 wt%, in 100 wt% of the solids in the photosensitive resin composition. Within this range, it is possible to obtain an insulating film having a high elastic modulus that can withstand a sealing step of a hollow structure.

[0044]

In addition, in order to disperse the glass filler (B) in the photosensitive resin composition, a surface treatment with a silane coupling agent may be performed, as necessary.

As a specific example of the silane coupling agent, vinyltrimethoxysilane (KBM-1003), 3-glycidoxypropyltrimethoxysilane (KBM-403), 3-methacryloxypropyltrimethoxysilane (KBM-503), N-2-(aminoethyl)-3-aminopropyltrimethoxysilane (KBM-603), N-phenyl-3-aminopropyltrimethoxysilane (KBM-603), and the like of Shin-Etsu Chemical Co., Ltd. can be used. The surface treatment for the glass filler can be performed by a dry surface treatment in which a silane coupling agent and a small amount of water are added to the glass filler and stirring is performed.

[0045]

The photosensitive resin composition of the present invention contains the photopolymerizable compound (C). The photopolymerizable compound is a compound that can be polymerized by an active species such as a radical or a cation generated by exposure, and a polymerizable monomer having a (meth)acrylic group or a polymerizable monomer having a glycidyl group is used.

[0046]

As the polymerizable monomer having a (meth)acrylic group, a compound having one or two or more (meth)acrylic groups in the molecule can be used, and examples thereof include diethylene glycol diacrylate, triethylene glycol diacrylate, tetraethylene glycol diacrylate, diethylene glycol dimethacrylate, triethylene glycol dimethacrylate,

tetraethylene glycol dimethacrylate, trimethylolpropane diacrylate, trimethylolpropane triacrylate, trimethylolpropane dimethacrylate, trimethylolpropane trimethacrylate, butyl acrylate, butyl methacrylate, isobutyl acrylate, hexyl acrylate, isooctyl acrylate, isobornyl acrylate, isobornyl methacrylate, cyclohexyl methacrylate, glycidyl methacrylate, 4-hydroxybutyl acrylate glycidyl ether, 1,3-butanediol diacrylate, 1,3-butanediol dimethacrylate, neopentyl glycol diacrylate, 1,4-butanediol diacrylate, 1,4-butanediol dimethacrylate, 1,6-hexanediol diacrylate, 1,6-hexanediol dimethacrylate, 1,9-nonanediol dimethacrylate, 1,10-decanediol dimethacrylate, dimethylol tricyclodecane diacrylate, pentaerythritol triacrylate, pentaerythritol tetraacrylate, pentaerythritol trimethacrylate, pentaerythritol tetramethacrylate, dipentaerythritol hexaacrylate, dipentaerythritol hexamethacrylate, 2-hydroxyethyl acrylate, 2-hydroxyethyl methacrylate, 1,3-diacryloyloxy-2-hydroxy propane, 1,3-dimethacryloyloxy-2-hydroxypropane, 2,2,6,6-tetramethylpiperidinyll methacrylate, 2,2,6,6-tetramethylpiperidinyll acrylate, N-methyl-2,2,6,6-tetramethylpiperidinyll methacrylate, N-methyl-2,2,6,6-tetramethylpiperidinyll acrylate, ethylene oxide-modified bisphenol A diacrylate, ethylene oxide-modified bisphenol A dimethacrylate, propylene

oxide-modified bisphenol A diacrylate, propylene oxide-modified bisphenol A methacrylate, propoxylated ethoxylated bisphenol A diacrylate, propoxylated ethoxylated bisphenol A dimethacrylate, ethylene oxide-modified pentaerythritol tetramethacrylate, propylene oxide-modified pentaerythritol tetraacrylate, and the like. These are used alone or in combination of two or more thereof.

[0047]

As the polymerizable monomer having a glycidyl group, a compound having one or two or more glycidyl groups in the molecule can be used, and examples thereof include epoxy resins such as jER 828, jER1002, jER1750, jER152, jER157S70, jER YL980, and jER630LSD (manufactured by Mitsubishi Chemical Corporation), ADEKA RESIN EP-4100HF, ADEKA RESIN EP-4901HF, ADEKA RESIN EP-4000S, ADEKA RESIN EP-4000L, ADEKA RESIN EP-4003S, ADEKA RESIN EP-4010S, and ADEKA RESIN EP-4010L (manufactured by ADEKA CORPORATION), EPICLON HP7200, EPICLON HP4032, EPICLON N-865, and EPICLON EXA-850CRP (manufactured by DIC Corporation), YD-825GS and YDCN-704 (manufactured by NIPPON STEEL Chemical & Material Co., Ltd.), EOCN-1020 and NC3000 (manufactured by Nippon Kayaku), and LX-01 (manufactured by Daiso Co., Ltd.). These may be used alone or in combination of two or more thereof.

[0048]

A content of the photopolymerizable compound (C) in the

photosensitive resin composition of the present invention is preferably in a range of 5 to 40 wt% in 100 wt% of the solids in the photosensitive resin composition. Within this range, excellent pattern-processability can be obtained.

[0049]

The photosensitive resin composition of the present invention contains the photopolymerization initiator (D). Examples of the photopolymerization initiator include a photopolymerization initiator that generates a radical by irradiation with ultraviolet rays and a photoacid generator that generates an acid, and these photopolymerization initiators can promote radical polymerization of a polymerizable monomer having a (meth)acrylic group and cationic polymerization of a polymerizable monomer having a glycidyl group, respectively. Examples of the photopolymerization initiator that generates a radical include benzophenones, glycines, mercaptos, oximes, acylphosphines, α -aminoalkylphenones, and the like, and among them, acylphosphines and oximes are preferably used. These photopolymerization initiators may be used alone or in combination of two or more thereof.

[0050]

Specific examples of the photopolymerization initiator include benzophenones such as benzophenone, Michler's ketone, 4,4'-bis(diethylamino)benzophenone, and

3,3,4,4,-tetra(t-butylperoxycarbonyl)benzophenone,
benzylidenes such as
3,5-bis(diethylaminobenzylidene)-N-methyl-4-piperidone and
3,5-bis(diethylaminobenzylidene)-N-ethyl-4-piperidone,
coumarins such as 7-diethylamino-3-nonylcoumarin,
4,6-dimethyl-3-ethylaminocoumarin,
3,3-carbonylbis(7-diethylaminocoumarin),
7-diethylamino-3-(1-methylmethylbenzoimidazolyl)coumarin,
and 3-(2-benzothiazolyl)-7-diethylaminocoumarin,
anthraquinones such as 2-t-butyl anthraquinone, 2-ethyl
anthraquinone, and 1,2-benzanthraquinone, benzoin such as
benzoin methyl ether, benzoin ethyl ether, and benzoin
isopropyl ether, thioxanthenes such as
2,4-dimethylthioxanthone, 2,4-diethylthioxanthone,
2,4-diisopropylthioxanthone, and 2-isopropylthioxanthone,
mercaptos such as ethylene glycol di(3-mercaptopropionate),
2-mercaptobenzthiazole, 2-mercaptobenzoxazole, and
2-mercaptobenzimidazole, glycines such as N-phenylglycine,
N-methyl-N-phenylglycine, N-ethyl-N-(p-chlorophenyl)glycine,
and N-(4-cyanophenyl)glycine, oximes such as
1-phenyl-1,2-butanedione-2-(o-methoxycarbonyl)oxime,
1-phenyl-1,2-propanedione-2-(o-methoxycarbonyl)oxime,
1-phenyl-1,2-propanedione-2-(o-ethoxycarbonyl)oxime,
1-phenyl-1,2-propanedione-2-(o-benzoyl)oxime,
bis(α -isonitrosopropiophenone oxime)isophthal,

1,2-octanedione-1-[4-(phenylthio)phenyl]-2-(o-benzoyloxime),
 and
 ethanone-1-[9-ethyl-6-(2-methylbenzoyl)-9H-carbazol-3-yl]-1
 -(o-acetyloxime), acylphosphines such as
 2,4,6-trimethylbenzoyl-diphenyl-phosphine oxide and
 bis(2,4,6-trimethylbenzoyl)-phenylphosphine oxide,
 α -aminoalkylphenones such as
 2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)-butan-1-one
 and
 2-methyl-1-[4-(methylthio)phenyl]-2-morpholinopropan-1-one,
 2,2'-bis(o-chlorophenyl)-4,4',5,5'-tetraphenylbiimidazole,
 and the like.

[0051]

Among them, examples of preferred acylphosphines and
 oximes include 2,4,6-trimethylbenzoyl-diphenyl-phosphine
 oxide, bis(2,4,6-trimethylbenzoyl)-phenylphosphine oxide,
 1-phenyl-1,2-propanedione-2-(o-ethoxycarbonyl)oxime,
 1-phenyl-1,2-propanedione-2-(o-benzoyl)oxime,
 bis(α -isonitrosopropiophenone oxime)isophthal,
 1,2-octanedione-1-[4-(phenylthio)phenyl]-2-(o-benzoyloxime)
],
 ethanone-1-[9-ethyl-6-(2-methylbenzoyl)-9H-carbazol-3-yl]-1
 -(o-acetyloxime), and compounds selected from ADEKA ARKLS
 (registered trademark) N-1919, NCI-831, and NCI-930
 manufactured by ADEKA CORPORATION) and OXE-01, OXE-02, and

OXE-04 manufactured by BASF SE.

[0052]

Examples of the photoacid generator include quinone diazides, diazodisulfones, triphenylsulfoniums, diphenyliodoniums, and the like. Among them, quinone diazides are preferably used. These photoacid generators may be used alone or in combination of two or more thereof.

[0053]

A content of the photopolymerization initiator (D) in the photosensitive resin composition of the present invention is preferably in a range of 0.05 to 5 wt% in 100 wt% of the solids in the photosensitive resin composition. Within this range, excellent pattern-processability can be obtained.

[0054]

It is preferable that the photosensitive resin composition of the present invention contains a thermal crosslinking agent (E). The thermal crosslinking agent is a component that is cured by a heat treatment after pattern processing, such that an insulating film having high reliability can be obtained. As the thermal crosslinking agent, for example, a compound having one or two or more glycidyl groups in the molecule can be used.

[0055]

As the compound having one or two or more glycidyl groups in the molecule, which is one of the thermal crosslinking agents

(E), epoxy resins such as jER 828, jER1002, jER1750, jER152, jER157S70, jER YL980, and jER630LSD (manufactured by Mitsubishi Chemical Corporation), ADEKA RESIN EP-4100HF, ADEKA RESIN EP-4901HF, ADEKA RESIN EP-4000S, ADEKA RESIN EP-4000L, ADEKA RESIN EP-4003S, ADEKA RESIN EP-4010S, and ADEKA RESIN EP-4010L (manufactured by ADEKA CORPORATION), EPICLON HP7200, EPICLON HP4032, EPICLON N-865, and EPICLON EXA-850CRP (all manufactured by DIC Corporation), YD-825GS and YDCN-704 (all manufactured by NIPPON STEEL Chemical & Material Co., Ltd.), EOCN-1020 and NC3000 (all manufactured by Nippon Kayaku), and LX-01 (manufactured by Daiso Co., Ltd.) can be used.

[0056]

In addition, a benzoxazine compound is also preferably used as the thermal crosslinking agent (E), and a thermal crosslinking agent containing at least two thermal crosslinking groups is preferable. Examples of the thermal crosslinking agent containing at least two thermal crosslinking groups include 46DMOC and 46DMOEP (trade name, manufactured by ASAHI YUKIZAI CORPORATION), DML-MBPC, DML-MBOC, DML-OCHP, DML-PC, DML-PCHP, DML-PTBP, DML-34X, DML-EP, DML-POP, Dimethyrol-BisOC-P, DML-PFP, DML-PSBP, DML-MTrisPC, and DMOM-PTBP (trade name, manufactured by Honshu Chemical Industry Co., Ltd.), "NIKALAC" (registered trademark) MX-290 (trade name, manufactured by Sanwa Chemical Co., Ltd.), Type B-a Benzoxazine and Type B-m Benzoxazine (trade name, manufactured by Shikoku

Chemicals Corporation), 2,6-dimethoxymethyl-4-t-butylphenol, 2,6-dimethoxymethyl-p-cresol, 2,6-diacetoxymethyl-p-cresol, and the like. In addition, examples of a thermal crosslinking agent containing three thermal crosslinking groups include TriML-P and TriML-35XL (trade name, manufactured by Honshu Chemical Industry Co., Ltd.) and the like. Examples of a thermal crosslinking agent containing four thermal crosslinking groups include TM-BIP-A (trade name, ASAHI YUKIZAI CORPORATION), TML-BP, TML-HQ, TML-pp-BPF, TML-BPA, and TMOM-BP (trade name, manufactured by Honshu Chemical Industry Co., Ltd.), NIKALAC MX-280 and NIKALAC MX-270 (trade name, manufactured by Sanwa Chemical Co., Ltd.), and the like. Examples of a thermal crosslinking agent containing six thermal crosslinking groups include HML-TPPHBA, HML-TPHAP, HMOM-TPPHBA, and HMOM-TPHAP (trade name, manufactured by Honshu Chemical Industry Co., Ltd.), and the like.

[0057]

A content of the thermal crosslinking agent (E) in the photosensitive resin composition of the present invention is preferably in a range of 2 to 30 wt% in 100 wt% of the solids in the photosensitive resin composition. Within this range, excellent pattern-processability and high reliability of an insulating film after the heat treatment can be obtained.

[0058]

In addition, the photosensitive resin composition of the

present invention may further contain a polymerization inhibitor. By containing the polymerization inhibitor, a concentration of excitons is adjusted, such that a pattern having a rectangular cross-sectional shape can be formed. In addition, excessive photoresponsiveness can be suppressed by the polymerization inhibitor, and an exposure margin can be widened.

[0059]

Examples of the polymerization inhibitor include a phenolic polymerization inhibitor such as hydroquinone, hydroquinone monomethyl ether, or t-butylcatechol, phenothiazine, 2-methoxyphenothiazine, 1-naphthol, 1,4-dihydroxynaphthalene, 4-methoxy-1-naphthol, 1-methoxynaphthalene, 1,4-dimethoxynaphthalene, 2,6-dimethoxynaphthalene, 2,7-dimethoxynaphthalene, 1,4-diethoxynaphthalene, 2,6-diethoxynaphthalene, 2,7-diethoxynaphthalene, 2,6-dibutoxynaphthalene, 2-ethyl-1,4-diethoxynaphthalene, 1,4-dibutoxy naphthalene, 1,4-diphenethyloxynaphthalene, 1,4-naphthoquinone, 2-hydroxy-1,4-naphthoquinone, 2-methyl-1,4-naphthoquinone, 9-butoxyanthracene, 9,10-butoxyanthracene, 9-anthrone, 9,10-anthraquinone, 2-ethyl-9,10-anthraquinone, and the like. These polymerization inhibitors are used alone or in combination of two or more thereof.

[0060]

The photosensitive resin composition of the present invention may contain a sensitizer, an adhesion improver, a colorant, a dispersant, and the like, as necessary.

[0061]

Next, an example of a method for producing a photosensitive resin composition of the present invention will be described. A first aspect of the photosensitive resin composition of the present invention is a varnish material obtained by dissolving and diluting various raw materials in a solvent. Examples of the dissolution method include ultrasonic waves, blade stirring, a ball mill, and the like, and filtration with a filter may be performed, as necessary. The filtration method is not particularly limited, but a method of performing filtration by pressure filtration using a filter having a retained particle diameter of 1 μm to 50 μm is preferable. The solvent used for dilution is not particularly limited, and examples thereof include ethers such as ethylene glycol monomethyl ether, ethylene glycol monoethyl ether, propylene glycol monomethyl ether, propylene glycol monoethyl ether, ethylene glycol dimethyl ether, ethylene glycol diethyl ether, and ethylene glycol dibutyl ether, acetates such as ethylene glycol monoethyl ether acetate, propylene glycol monomethyl ether acetate, propyl acetate, butyl acetate, isobutyl acetate, 3-methoxybutyl acetate, 3-methyl-3-methoxybutyl acetate, methyl lactate, ethyl lactate, and butyl lactate, ketones such

as acetone, methyl ethyl ketone, acetyl acetone, methyl propyl ketone, methyl butyl ketone, methyl isobutyl ketone, cyclopentanone, and 2-heptanone, alcohols such as butyl alcohol, isobutyl alcohol, pentanol, 4-methyl-2-pentanol, 3-methyl-2-butanol, 3-methyl-3-methoxy butanol, and diacetone alcohol, aromatic hydrocarbons such as toluene and xylene, N-methyl-2-pyrrolidone, N-cyclohexyl-2-pyrrolidone, N,N-dimethylformamide, N,N-dimethylacetamide, dimethylsulfoxide, γ -butyrolactone, and the like.

[0062]

A second aspect of the photosensitive resin composition of the present invention is a photosensitive resin sheet in which a layer formed of a photosensitive resin composition is formed on a support film by applying the photosensitive resin composition on a film that supports the photosensitive resin composition (also referred to as a support film) and drying the photosensitive resin composition. That is, the photosensitive resin sheet of the present invention is a sheet including a layer formed of the photosensitive resin composition of the present invention and a support film.

[0063]

The support film used in the photosensitive resin sheet of the present invention is not particularly limited, and various films that are commonly commercially available, such as a polyethylene terephthalate (PET) film, a polyphenylene

sulfide film, and a polyimide film, can be used. An interface between the support film and the photosensitive resin film is subjected to a surface treatment with silicone, a silane coupling agent, an aluminum chelating agent, polyurea, or the like in order to improve adhesion and peelability. A thickness of the support film is not particularly limited, and is preferably in a range of 10 to 100 μm from the viewpoint of workability. When the layer formed of the photosensitive resin composition is exposed, the layer can be exposed through the support film, and thus, a haze of the support film is preferably 0.1% or more and 2.0% or less, and more preferably 0.1% or more and 1.5% or less. When the haze is more than 2.0%, scattering of expose light occurs, resulting in deterioration of pattern-processability.

[0064]

The haze is an index indicating a transmittance of the support film, and a haze at a wavelength of 405 nm (HAZE_{405}) can be determined by measuring a transmittance of the support film by a spectrophotometer (U-3900 type spectrophotometer, manufactured by Hitachi High-Technologies Corporation) and substituting the transmittance into the following equation.

[0065]

$$\text{HAZE}_{405} = T2 - T1$$

T1 represents a transmittance at a wavelength of 405 nm measured without mounting an integrating sphere to the

spectrophotometer, and T2 represents a transmittance at a wavelength of 405 nm measured by mounting an integrating sphere to the spectrophotometer. As HAZE₄₀₅ is smaller, a scattering component of light is decreased, and straightness of light in the support film is more excellent.

[0066]

An oxygen permeability of the support film is preferably 10 to 400 cc/m². When the oxygen permeability of the support film is in the above range, it is possible to suppress oxygen contained in the air to contact with the photosensitive resin composition after exposure, that is, it is possible to suppress an oxygen bonding reaction of the photosensitive resin composition, and it is possible to obtain an excellent pattern shape. The oxygen permeability can be measured according to JIS-K7126 "Test Method for Plastic Film and Sheet Gas Permeability".

[0067]

In addition, in order to protect the photosensitive resin sheet, a protective film may be provided on the side of the layer in the photosensitive resin sheet including the layer formed of the photosensitive resin composition and the support film. Therefore, a surface of the layer formed of the photosensitive resin composition of the photosensitive resin sheet can be protected from contaminants such as dust and dirt in the air. Examples of the protective film include a polyethylene film,

a polypropylene (PP) film, a polyester film, a polyvinyl alcohol film, and the like. In the protective film, it is preferable that the layer formed of the photosensitive resin composition and the protective film are not easily peeled off.

[0068]

Examples of the method for applying the photosensitive resin composition to the support film include methods such as spin coating using a spinner, spray coating, roll coating, screen printing, blade coater, die coater, calender coater, meniscus coater, bar coater, roll coater, comma roll coater, gravure coater, screen coater, and slit die coater. In addition, a thickness of a coating film varies depending on the application method, the solid concentration and the viscosity of the composition, and the like, and the film thickness after drying is preferably 3.0 μm or more and 100 μm or less.

[0069]

In the photosensitive resin sheet of the present invention, a thickness of the layer formed of the photosensitive resin composition is preferably 10 to 50 μm . In particular, in a case where a cured material of the present invention is used as a roof material for a hollow structure of an electronic component, the thickness of the layer formed of the photosensitive resin composition in the photosensitive resin sheet of the present invention is preferably 50 μm or less from the viewpoint of a reduction in height the electronic component,

and more preferably 10 μm or more from the viewpoint of pressure resistance. An oven, a hot plate, infrared rays, and the like can be used in the drying. The drying temperature and the drying time may be in a range in which an organic solvent can be volatilized, and it is preferable to appropriately set a range in which the photosensitive resin sheet is in an uncured or semi-cured state. Specifically, the drying is preferably performed in a range of 40°C to 120°C for 1 minute to several tens of minutes. In addition, the temperature may be increased stepwise by combining these temperatures, and for example, the heat treatment may be performed at 50°C, 60°C, and 70°C for 1 minute each.

[0070]

A melt viscosity at 80°C of the layer formed of the photosensitive resin composition of the present invention in the photosensitive resin sheet is preferably 10,000 to 500,000 Pa•s. When the melt viscosity is more than 500,000 Pa•s, adhesiveness of the layer formed of the photosensitive resin composition is insufficient, which causes poor bonding to an adherend. In addition, when the melt viscosity is 200,000 Pa•s or less, the bonding temperature can be lowered, which is more preferable. There is no limitation on a low viscosity, but in a case of use for forming a hollow structure, when bonding is performed only on a convex portion of an adherend, if the melt viscosity is less than 10,000 Pa•s, the layer formed of the

photosensitive resin composition is too soft. Therefore, it is difficult to bond only on the convex portion.

[0071]

The melt viscosity of the layer formed of the photosensitive resin composition in the photosensitive resin sheet (hereinafter, the layer formed of the photosensitive resin composition is referred to as a photosensitive resin layer) can be measured by the following method. The protective film is peeled off from the photosensitive resin sheet, and the photosensitive resin layers are bonded to each other with a roll laminator heated to 80°C. The support film formed on one surface of a laminate is peeled off, and the photosensitive resin layers are bonded to each other again. This operation is repeated to obtain a laminate of the photosensitive resin layers having a thickness 200 to 800 μm . The support films formed on both surfaces of the laminate are peeled off, the laminate is sandwiched between probes having a diameter of 15 mm of a viscoelasticity measuring device, measurement is performed at a temperature rising rate of 2°C/min in a range of 40°C to 100°C, and a complex viscosity at 80°C is defined as a melt viscosity.

[0072]

The cured material of the present invention is a cured material of the photosensitive resin composition. The cured material of the photosensitive resin composition can be

obtained by photocuring and thermally curing the photosensitive resin composition.

[0073]

A water vapor permeability of the cured material is preferably in a range of 50 to 200 g/(m²•day) when a thickness of the cured material is 20 μm. Within this range, an influence of water vapor in a reliability test of an electronic component to which the cured material of the photosensitive resin composition is applied can be reduced, and characteristic deterioration in the reliability test can be suppressed.

[0074]

The hollow structure of the present invention is a hollow structure including the cured material of the photosensitive resin composition of the present invention as a roof material. The hollow structure as used here refers to a structure in which a space (hereinafter, referred to as a "hollow portion") is formed, the space being closed by a substrate, a convex portion formed on the substrate and provided to surround a part of a surface of the substrate, and a film-shaped material in contact with a top of the convex portion. The convex portion formed on the substrate of the hollow structure may be referred to as a wall or a wall material. In addition, the film-shaped material provided so as to be in contact with the top of the convex portion is referred to as a roof or a roof material.

[0075]

The convex portion of the hollow structure may be formed on a substrate by printing of a resin material or photolithographic processing of a photosensitive material, or a recess may be formed by scraping a substrate by a method such as dry etching to relatively form a convex portion. In a case where the convex portion is formed of a photosensitive material, it is preferable to contain polyimide from the viewpoint of reliability.

[0076]

A width of the convex portion of the hollow structure is preferably 15 μm or more from the viewpoint of imparting strength to the hollow structure, and is preferably 300 μm or less from the viewpoint of downsizing the hollow structure. A height is not particularly limited, but is preferably 30 μm or less from the viewpoint of a reduction in height of the hollow structure, and is preferably 5 μm or more from the viewpoint of maintaining a hollow of the hollow structure. An area of the substrate in the hollow portion is preferably in a range of 0.01 to 1.0 mm^2 . When the area is smaller than this range, it is difficult to dispose an internal electrode in the hollow portion, and when the area is larger than this range, there is a concern that the photosensitive resin sheet and the substrate are grounded by the weight of the photosensitive resin sheet. The inside surrounded by the convex portion may have independent convex portions and convex portions continuous with an outer

wall. The area of the substrate in the hollow portion is an area of the inside surrounded by the convex portion of the substrate, and can be measured with a microscope capable of measuring a length. In addition, the width of the convex portion of the substrate is a distance (x in Fig. 1A) between an inner wall surface and an outer wall surface of the convex portion (the convex portion as an outer wall) surrounding the substrate, and can be measured with a microscope capable of measuring a length.

[0077]

A method for forming a hollow structure using the photosensitive resin sheet of the present invention includes the following steps:

step 1: a step of forming a convex portion on a substrate;

step 2: a step of bonding the photosensitive resin layer side of the photosensitive resin sheet onto the convex portion of the substrate;

step 3: a step of exposing the photosensitive resin layer through the support film;

step 4: a step of peeling off the support film;

step 5: a step of developing the photosensitive resin layer; and

step 6: a step of thermally curing the photosensitive resin layer to form a cured material.

Each step will be described in detail with reference to

Fig. 1A and Fig. 1B.

[0078]

First, as described above, the convex portion is formed on the substrate by a method for forming a convex portion by printing a resin material or photolithographic processing of a photosensitive material on a substrate, a method for forming a recess by scraping a substrate by a method such as dry etching to relatively form a convex portion, or the like.

[0079]

Next, a photosensitive resin layer side of a photosensitive resin sheet is bonded onto the convex portion of the substrate. In Fig. 1A and (a) of Fig. 1B, as a representative example, a width x of a convex portion 2 is 50 μm , a high y of the convex portion 2 is 20 μm , and an area ($w \times z$) of a substrate 1 in a hollow portion is 0.25 mm^2 , but the dimensions are not limited thereto.

[0080]

A protective film is peeled off from the photosensitive resin sheet, a layer 4 formed of a photosensitive resin composition is disposed so as to face the substrate 1 on which the convex portion 2 is formed, and a roll comes contact with a roll laminator from a support film 3 side so as to bond them together ((b) of Fig. 1B). The bonding temperature or pressure depend on the shape of the convex portion formed on the substrate, and are preferably 50 to 80°C and 0.05 to 0.3 MPa, respectively.

[0081]

Subsequently, exposure is performed by a photomask capable of forming a pattern covering the convex portion 2 with an exposure machine using an ultra-high pressure mercury lamp, an LED, a laser, or the like that emits light including ultraviolet rays having a wavelength of 405 nm as a light source. The layer 4 formed of the photosensitive resin composition becomes a layer 5 in which a desired pattern is photocured by exposure ((c) of Fig. 1B). After the exposure, a heat treatment may be performed at a temperature of 40°C or higher and 150°C or lower for 5 seconds or longer and 60 minutes or shorter using an oven or a hot plate.

[0082]

Subsequently, the support film 3 is peeled off ((d) of Fig. 1B). The support film may be peeled off immediately after the exposure, or may be peeled off after the heat treatment after the exposure. Subsequently, development is performed ((e) of Fig. 1B). An unexposed portion is removed using a developer, a rinsing treatment is performed, and then, spin drying is performed. Examples of the developer include alkali developers such as a tetramethylammonium hydroxide (TMAH) aqueous solution and a sodium carbonate aqueous solution, developers such as cyclohexanone and propylene glycol methyl ether acetate (PGMEA), and the like, and can be appropriately selected depending on the solubility of the photosensitive

resin layer. In a case where an alkali aqueous solution is used, it is preferable to perform rinsing with pure water after completion of development. The temperature of the developer and the developing time are appropriately set depending on the pattern shape and the like, and are preferably 20 to 30°C and 30 seconds to 10 minutes, respectively.

[0083]

Furthermore, a heat treatment is performed to completely cure the photosensitive resin composition, thereby obtaining a hollow structure having a cured material 6 of the photosensitive resin composition ((f) of Fig. 1B). Heat resistance and chemical resistance can be improved by completely curing the photosensitive resin composition by thermal curing.

[0084]

The heating temperature at which these characteristics are improved is preferably 150°C or higher, and more preferably 180°C or higher. In addition, the heating temperature is preferably 350°C or lower, and more preferably 300°C or lower, because the characteristics are deteriorated when thermal decomposition of the photosensitive resin layer occurs.

[0085]

The hollow structure of the present invention is used for an electronic component having a hollow structure. Examples of the electronic component having a hollow structure include

an elastic wave filter and the like. The electronic component having a hollow structure of the present invention is an elastic wave filter.

[0086]

In addition, the cured material of the present invention can form an insulating film that is excellent in pattern-processability and has high reliability, and thus can be suitably used for an electronic component other than an elastic wave filter.

[0087]

The application of the cured material is not particularly limited, but the cured material can be applied to, for example, a surface protective film built in a substrate and a package for a system using a semiconductor, such as a mounted substrate and a wafer level package, an interlayer insulating film, a resist such as a wiring protective insulating film for a circuit board, and various electronic components and devices. In addition, due to its excellent heat resistance, the cured material can be suitably used particularly for an adhesive in which a permanent resist, that is, a patterned interlayer insulating film, a pattern formed substrate, glass, a semiconductor element, or the like is subjected to thermocompression bond to an adherend.

EXAMPLES

[0088]

<Total Content of Rare Earth Oxides>

Measurement was performed using X-ray fluorescence analysis. A glass filler was formed into a disk shape by a press machine, and then, elements contained in the glass filler were quantitatively analyzed using a wavelength dispersive X-ray fluorescence spectrometer XRF-1800 manufactured by Shimadzu Corporation to calculate the total content of rare earth oxides.

<Total Amount of Magnesium Ions, Calcium Ions, and Zinc Ions>

A vessel was charged with 3 g of a glass filler and 30 mL of ultrapure water, the vessel was sealed and placed in a thermostat at 121°C, and an extraction treatment was performed for 24 hours. The obtained extract was analyzed by an ion chromatography analyzer, and the extraction amounts of magnesium ions, calcium ions, and zinc ions were converted from a calibration curve using a standard solution of each ion. The sum of the respective converted ions was taken as the total amount of magnesium ions, calcium ions, and zinc ions.

<Refractive Index of Glass Filler>

Measurement was performed by V block method. After 50 g of the glass filler was melted at 1,500°C for 4 hours using a platinum crucible, the melt was poured into a carbon mold and slowly cooled to obtain a glass block. The obtained glass block was processed into a rectangular parallelepiped shape of 10 mm or more × 10 mm or more × 10 mm or more, and a refractive index at a wavelength of 405 nm was measured using a precision

refractometer KPR-2000 manufactured by Shimadzu Device Corporation.

<Refractive Index of Organic Component (Excluding Solvent) Obtained by Removing Glass Filler From Photosensitive Resin Composition>

Only the organic component in the photosensitive resin composition was prepared and applied onto a silicon wafer, and drying was performed. The refractive index at a wavelength of 405 nm at 25°C was measured by ellipsometry using a spectroscopic ellipsometer SE-2000 manufactured by Semilab Inc.

<Oxygen Permeability of Support Film>

An oxygen permeability was measured according to JIS-K7126 "Test Method for Plastic Film and Sheet Gas Permeability" using an oxygen permeability measuring device OX-TRAN 1/50 manufactured by MOCON Inc.

<Water Vapor Permeability>

A cured material (thickness of 20 μm and size of 80 mm $\times$ 80 mm) obtained by exposing and thermally curing the photosensitive resin composition was prepared, and a water vapor permeability was measured using a moisture permeation cup (70 mm ϕ and depth of 25 mm) and calcium chloride (for moisture measurement, Wako Pure Chemical Industries, Ltd., 030-00525) in accordance with JIS-Z0208 "Moisture Permeability Test Method for Moisture-Proof Packaging Material" (cup method) using a constant temperature and humidity apparatus set at 40°C and a

relative humidity of 90%.

<Area of Substrate in Hollow Portion and Width of Convex Portion of Substrate>

Using a microscope VHX-6000 manufactured by Keyence Corporation as a microscope capable of measuring a length, a width (x in Fig. 1A) of the convex portion was measured under a condition of a magnification of 500 times. Similarly, an area ($w \times z$ in FIG. 1A) of the substrate in the hollow portion was measured.

<Thickness of Photosensitive Resin Composition>

A thickness of the photosensitive resin composition was measured using DIGIMICRO MH-15M manufactured by Nikon Corporation, which was a contact type film thickness meter, after the photosensitive resin composition was applied onto a silicon wafer and drying was performed.

<Thickness of Photosensitive Resin Sheet>

A thickness of the photosensitive resin sheet was measured using DIGIMICRO MH-15M manufactured by Nikon Corporation, which was a contact type film thickness meter, after the photosensitive resin composition was applied onto a support film and drying was performed.

<Evaluation of Resolution>

In each of the photosensitive resin compositions of Examples 1 to 10 and Comparative Examples 1 and 2, the photosensitive resin composition was applied onto a silicon

wafer by spin coating, and drying was performed at 80°C for 5 minutes to form a layer formed of the photosensitive resin composition on the silicon wafer. Spin conditions were adjusted so that a thickness of the layer formed of the photosensitive resin composition after the drying was 20 μm .
[0089]

In each of the photosensitive resin sheets of Examples 11 to 18, the polypropylene film was peeled from the photosensitive resin sheet, the layer formed of the photosensitive resin composition was disposed so as to face the silicon wafer, roll lamination was performed under the conditions of 80°C and 0.3 MPa, and then the polyethylene terephthalate film was peeled off, thereby forming a layer formed of the photosensitive resin composition on the silicon wafer.

[0090]

A photomask in which 20 via patterns having via diameters of 5, 10, 15, and up to 100 μm at intervals of 5 μm were arranged was placed on the obtained layer formed of the photosensitive resin composition, and exposure was performed with an exposure amount of 400 mJ/cm² (using i-line cut filter, in terms of h-line) using an ultra-high pressure mercury lamp as a light source. After the exposure, heating was performed on a hot plate at 100°C for 5 minutes. Next, an unexposed portion was removed by shower development for 200 seconds using a 2.38 wt%

aqueous solution of tetramethylammonium hydroxide, a rinsing treatment was performed with water for 60 seconds, and then spin drying was performed. Further, a heat treatment was performed at 200°C for 60 minutes in an inert oven to form an insulating film in which the via patterns were processed on the silicon water.

[0091]

The via patterns were observed with a microscope, and the minimum dimension at which the via was opened was defined as a resolution. The opening of the via as used here was defined as a via opening when 50% or more of a design value of the photomask was opened. A case where a via of 40 μm or less was opened was determined as A, a case where a via of 45 μm to 50 μm was opened was determined as B, a case where a via of 55 to 60 μm was opened was determined as C, and a case where a via of 65 μm to 100 μm was opened was determined as D.

<Evaluation of Humidity Resistance>

The silicon wafer on which the insulating film obtained by processing the via patterns was formed was put into a pressure cooker tester, and a test was performed under conditions of 121°C and 100% for 500 hours. After the test, the wafer was taken out and drying was performed. The presence or absence of a precipitate derived from an eluate from the glass filler was observed around the via of 100 μm with a microscope or an electron microscope, and a case where no precipitate derived from the

eluate from the glass filler was observed was determined as A, and a case where a precipitate derived from the eluate from the glass filler was observed was determined as B.

[0092]

Hereinafter, the present invention will be specifically described with reference to Examples and Comparative Examples, but the present invention is not limited to these Examples.

[0093]

<Alkali-Soluble Polymer (A-1)>

Polyimide:

Alkali-soluble polyimide synthesized by the following method was used.

[0094]

In a dry nitrogen stream, 36.26 g (0.099 mol) of 2,2-bis(3-amino-4 hydroxyphenyl)hexafluoropropane and 3.93 g (0.036 mol) of 3-aminophenol were dissolved in 163.39 g of γ -butyrolactone (hereinafter, referred to as GBL), and stirring was performed at 70°C for 60 minutes. 2.24 g (0.009 mol) of 1,3 bis(3-aminopropyl)tetramethyldisiloxane, 24.00 g (0.054 mol) of polypropylene glycol diamine, and 20.00 g of GBL were added thereto, and stirring was performed for 15 minutes. 55.84 g (0.180 mol) of bis(3,4-dicarboxyphenyl) ether dianhydride was added thereto, and stirring was performed for 15 minutes and then stirring was performed at 220°C for 5 hours, thereby obtaining an alkali-soluble polyimide resin solution (solid

concentration of 40 wt%). An imidization ratio of the obtained resin was 95%.

[0095]

<Glass Filler (B)>

Glass Filler 1

A glass filler containing 45 wt% of silicon oxide (hereinafter, also referred to as SiO_2), 25 wt% of aluminum oxide (hereinafter, also referred to as Al_2O_3), 4 wt% of boron oxide (hereinafter, also referred to as B_2O_3), and 26 wt% of yttrium oxide (hereinafter, also referred to as Y_2O_3). Refractive index (wavelength of 405 nm): 1.61, average particle diameter: 1.2 μm , extracted ion amount (total amount of magnesium ions, calcium ions, and zinc ions): 7 ppm (weight basis).

[0096]

Glass Filler 2

A glass filler containing 45 wt% of SiO_2 , 25 wt% of Al_2O_3 , 4 wt% of B_2O_3 , and 26 wt% of Y_2O_3 . Refractive index (wavelength of 405 nm): 1.61, average particle diameter: 3.0 μm , extracted ion amount (total amount of magnesium ions, calcium ions, and zinc ions): 7 ppm (weight basis).

[0097]

Glass Filler 3

A glass filler containing 45 wt% of SiO_2 , 25 wt% of Al_2O_3 , 4 wt% of B_2O_3 , and 26 wt% of Y_2O_3 . Refractive index (wavelength of 405 nm): 1.61, average particle diameter: 10.0 μm , extracted

ion amount (total amount of magnesium ions, calcium ions, and zinc ions): 7 ppm (weight basis).

[0098]

Glass Filler 4

A glass filler containing 42 wt% of SiO_2 , 28 wt% of Al_2O_3 , 4 wt% of B_2O_3 , and 26 wt% of Y_2O_3 . Refractive index (wavelength of 405 nm): 1.65, average particle diameter: 1.2 μm , extracted ion amount (total amount of magnesium ions, calcium ions, and zinc ions): 7 ppm (weight basis).

[0099]

Glass Filler 5

A glass filler containing 47 wt% of SiO_2 , 29 wt% of Al_2O_3 , and 24 wt% of Y_2O_3 . Refractive index (wavelength of 405 nm): 1.63, average particle diameter: 1.2 μm , extracted ion amount (total amount of magnesium ions, calcium ions, and zinc ions): 7 ppm (weight basis).

[0100]

Glass Filler 6

A glass filler containing 45 wt% of SiO_2 , 25 wt% of Al_2O_3 , 4 wt% of B_2O_3 , and 25 wt% of lanthanum oxide (hereinafter, also referred to as La_2O_3). Refractive index (wavelength of 405 nm): 1.67, average particle diameter: 1.2 μm , extracted ion amount (total amount of magnesium ions, calcium ions, and zinc ions): 7 ppm (weight basis).

[0101]

Glass Filler 7

A glass filler containing 45 wt% of SiO_2 , 25 wt% of Al_2O_3 , 4 wt% of B_2O_3 , and 25 wt% of neodymium oxide (hereinafter, also referred to as Nd_2O_3). Refractive index (wavelength of 405 nm): 1.67, average particle diameter: 1.2 μm , extracted ion amount (total amount of magnesium ions, calcium ions, and zinc ions): 7 ppm (weight basis).

[0102]

Glass Filler 8

A glass filler containing 46 wt% of SiO_2 , 17 wt% of Al_2O_3 , 27 wt% of zinc oxide (hereinafter, also referred to as ZnO) and 10 wt% of magnesium oxide (hereinafter, also referred to as MgO). Refractive index (wavelength of 405 nm): 1.61, average particle diameter: 1.2 μm , extracted ion amount (total amount of magnesium ions, calcium ions, and zinc ions): 150 ppm (weight basis).

[0103]

Silica

SO-E2 (Admatechs) Refractive index (wavelength of 405 nm): 1.47, average particle diameter: 0.5 μm , extracted ion amount (total amount of magnesium ions, calcium ions, and zinc ions): 2 ppm (weight basis).

[0104]

<Photopolymerizable Compound (C)>

BP-6 EM (Kyoisha Chemical Co., Ltd.)

<Photopolymerization Initiator (D)>

NCI-831 (ADEKA Corporation)

OXE-04 (BASF SE)

<Thermal Crosslinking Agent (E)>

HMOM-TPHAP (Honshu Chemical Industry Co., Ltd.)

<Polymerization Inhibitor>

Phenothiazine (Tokyo Chemical Industry Co., Ltd.)

<Adhesion Improver>

KBM-403 (Shin-Etsu Chemical Co., Ltd.)

<Dilution Solvent>

γ -Butyrolactone (Mitsubishi Chemical Corporation)

<Preparation of Photosensitive Resin Composition>

The preparation of the photosensitive resin composition of Example 1 will be described below as an example.

[0105]

An alkali-soluble polyimide resin solution (250 g (100 g as a solid content)) as the alkali-soluble polymer (A-1), a glass filler 1 (400 g) as the glass filler (B), BP-6EM (60 g) as the photopolymerizable compound (C), NCI-831 (10 g) as the photopolymerization initiator (D), HMOM-TPHAP (80 g (16 g as a solid content)) as the thermal crosslinking agent (E), phenothiazine (0.01 g) as the polymerization inhibitor, KBM-403 (3 g) as the adhesion improver, and γ -butyrolactone (270 g) as the dilution solvent were added, and stirring was performed at room temperature for 120 minutes, thereby preparing a

photosensitive resin composition. A refractive index at a wavelength of 405 nm of a resin component (excluding the solvent) of the photosensitive resin composition was 1.62. The mixing amount of the respective components and the physical properties of the photosensitive resin composition are shown in Table 1.

[0106]

In Example 2, a photosensitive resin composition similar to that of Example 1 was prepared by changing the photopolymerization initiator to the photopolymerization initiator shown in Table 1. In Examples 3 and 4, photosensitive resin compositions similar to that of Example 1 were prepared by changing the mixing amount of the glass filler 1 to the mixing amount shown in Table 1. In Examples 5 to 10, photosensitive resin compositions similar to that of Example 1 were prepared by changing the type of the glass filler 1 to the glass filler shown in Table 1.

[0107]

In Comparative Examples 1 and 2, photosensitive resin compositions similar to that of Example 1 were prepared by changing the glass filler 1 to the filler shown in Table 2.

[0108]

The physical properties of the obtained photosensitive resin compositions are shown in Table 1 or 2.

[0109]

<Production of Photosensitive Resin Sheet>

The production method of the photosensitive resin sheet of Example 11 will be described below as an example.

[0110]

The photosensitive resin composition of Example 1 was applied onto a polyethylene terephthalate film (support film) having a thickness of 50 μm , a haze of 0.7%, and an oxygen permeability of 20 cc/m² using a comma roll coater, and drying was performed at 80°C for 5 minutes. After the drying, a polypropylene film (protective film) having a thickness of 50 μm was laminated as a protective film to obtain a photosensitive resin sheet including the layer formed of the photosensitive resin composition and having a thickness of 20 μm . A melt viscosity of the layer formed of the photosensitive resin composition was 50,000 Pa•s.

[0111]

In Examples 12 to 16, photosensitive resin sheets were produced by the same method as that of Example 11, except that the clearance setting and drying conditions of the comma roll coater were adjusted to adjust the thickness and melt viscosity of the photosensitive resin sheet as shown in Table 2.

[0112]

In Example 17, a photosensitive resin sheet was produced by the same method as that of Example 11, except that the photosensitive resin composition of Example 1 was changed to

the photosensitive resin composition of Example 9. In Example 18, a photosensitive resin sheet was produced by the same method as that of Example 11, except that the photosensitive resin composition of Example 1 was changed to the photosensitive resin composition of Example 10.

[0113]

The results of evaluating the photosensitive resin sheets of Examples 11 to 18 are shown in Table 2.

[0114]

[Table 1-1]

			Example (photosensitive resin composition)				
			1	2	3	4	5
Composition	Alkali-soluble polymer (A-1)		250	250	250	250	250
	Filler	Glass Filler 1	400	400	100	750	
		Glass Filler 2					400
		Glass Filler 3					
		Glass Filler 4					
		Glass Filler 5					
		Glass Filler 6					
		Glass Filler 7					
		Glass Filler 8					
		Silica					
	Photopolymerizable compound (C)	BP-6EM	60	60	60	60	60
	Photopolymerization initiator (D)	NCI-831	10		10	10	10
		OXE-04		10			
	Thermal crosslinking agent (E)	HMOM-TPHAP	80	80	80	80	80
	Polymerization inhibitor	Phenothiazine	0.01	0.01	0.01	0.01	0.01
	Adhesion improver	KBM-403	3	3	3	3	3
	Diluent	γ -Butyrolactone	270	270	25	560	270
Content of glass filler (B) in 100 wt% of solids in photosensitive resin composition (wt%)			68	68	35	80	68
Absolute value of difference between refractive index of glass filler and refractive index of organic component (excluding solvent) obtained by removing glass filler from photosensitive resin composition			0.01	0.01	0.01	0.01	0.01
Thickness of layer in photosensitive resin sheet (μm)			—	—	—	—	—
Melt viscosity at 80°C of layer in photosensitive resin sheet ($\text{Pa}\cdot\text{s}$)			—	—	—	—	—
Evaluation results	Evaluation of resolution		A	A	A	A	A
	Evaluation of humidity resistance		A	A	A	A	A

[Table 1-2]

			Example (photosensitive resin composition)				
			6	7	8	9	10
Composition	Alkali-soluble polymer (A-1)		250	250	250	250	250
	Filler	Glass Filler 1					
		Glass Filler 2					
		Glass Filler 3	400				
		Glass Filler 4		400			
		Glass Filler 5			400		
		Glass Filler 6				400	
		Glass Filler 7					400
		Glass Filler 8					
		Silica					
	Photopolymerizable compound (C)	BP-6EM	60	60	60	60	60
	Photopolymerization initiator (D)	NCT-831	10	10	10	10	10
		OXE-04					
	Thermal crosslinking agent (E)	HMOM-TPHAP	80	80	80	80	80
	Polymerization inhibitor	Phenothiazine	0.01	0.03	0.20	0.20	0.20
	Adhesion improver	KBM-403	3	3	3	3	3
	Diluent	γ -Butyrolactone	270	270	270	270	270
Content of glass filler (B) in 100 wt% of solids in photosensitive resin composition (wt%)			68	68	68	68	68
Absolute value of difference between refractive index of glass filler and refractive index of organic component (excluding solvent) obtained by removing glass filler from photosensitive resin composition			0.01	0.03	0.01	0.05	0.05
Thickness of layer in photosensitive resin sheet (μm)			—	—	—	—	—
Melt viscosity at 80°C of layer in photosensitive resin sheet ($\text{Pa}\cdot\text{s}$)			—	—	—	—	—
Evaluation results	Evaluation of resolution		A	B	A	C	C
	Evaluation of humidity resistance		A	A	A	A	A

[0115]

[Table 2-1]

			Comparative Example		Example (photosensitive resin sheet)		
			1	2	11	12	13
Composition	Alkali-soluble polymer (A-1)		250	250	250	250	250
	Filler	Glass Filler 1			400	400	400
		Glass Filler 2					
		Glass Filler 3					
		Glass Filler 4					
		Glass Filler 5					
		Glass Filler 6					
		Glass Filler 7					
		Glass Filler 8	400				
		Silica		400			
	Photopolymerizable compound (C)	BP-6EM	60	60	60	60	60
	Photopolymerization initiator (D)	NCI-831 OXE-04	10 	10 	10 	10 	10
	Thermal crosslinking agent (E)	HMOM-TPHAP	80	80	80	80	80
	Polymerization inhibitor	Phenothiazine	0.01	0.20	0.01	0.01	0.01
	Adhesion improver	KBM-403	3	3	3	3	3
	Diluent	γ -Butyrolactone	270	270			
Content of glass filler (B) in 100 wt% of solids in photosensitive resin composition (wt%)			68	68	68	68	68
Absolute value of difference between refractive index of glass filler and refractive index of organic component (excluding solvent) obtained by removing glass filler from photosensitive resin composition			0.00	0.15	0.01	0.01	0.01
Thickness of layer in photosensitive resin sheet (μm)			—	—	20	10	40
Melt viscosity at 80°C of layer in photosensitive resin sheet ($\text{Pa}\cdot\text{s}$)			—	—	50,000	50,000	50,000
Evaluation results	Evaluation of resolution		A	D	A	A	B
	Evaluation of humidity resistance		B	A	A	A	A

[Table 2-2]

			Example (photosensitive resin sheet)				
			14	15	16	17	18
Composition	Alkali-soluble polymer (A-1)		250	250	250	250	250
	Filler	Glass Filler 1	400	400	400		
		Glass Filler 2					
		Glass Filler 3					
		Glass Filler 4					
		Glass Filler 5					
		Glass Filler 6				400	
		Glass Filler 7					400
		Glass Filler 8					
		Silica					
	Photopolymerizable compound (C)	BP-6EM	60	60	60	60	60
	Photopolymerization initiator (D)	NCT-831	10	10	10	10	10
		OXE-04					
	Thermal crosslinking agent (E)	HMOM-TPHAP	80	80	80	80	80
	Polymerization inhibitor	Phenothiazine	0.01	0.01	0.01	0.01	0.01
Evaluation results	Adhesion improver	KBM-403	3	3	3	3	3
	Diluent	γ -Butyrolactone					
Content of glass filler (B) in 100 wt% of solids in photosensitive resin composition (wt%)			68	68	68	68	68
Absolute value of difference between refractive index of glass filler and refractive index of organic component (excluding solvent) obtained by removing glass filler from photosensitive resin composition			0.01	0.01	0.01	0.05	0.05
Thickness of layer in photosensitive resin sheet (μm)			20	20	20	20	20
Melt viscosity at 80°C of layer in photosensitive resin sheet ($\text{Pa}\cdot\text{s}$)			10,000	100,000	200,000	50,000	50,000
Evaluation results	Evaluation of resolution		A	A	B	C	C
	Evaluation of humidity resistance		A	A	A	A	A

INDUSTRIAL APPLICABILITY

[0116]

An insulating film that is excellent in pattern-processability and pressure resistance and has high reliability can be formed. The insulating film obtained using the photosensitive resin composition of the present invention is excellent in electrical properties, mechanical properties, and heat resistance, and has high wet heat reliability, and thus is useful for a surface protective film and an interlayer

insulating film for a semiconductor element and an electronic component, a wiring protective insulating film for a circuit board, and the like. Further, the insulating film is useful for an electronic component having a hollow structure required to have pressure resistance, in particular, for a roof of a hollow structure such as an elastic wave filter or a crystal device.

DESCRIPTION OF REFERENCE SIGNS

[0117]

- 1: Substrate
- 2: Convex portion
- 3: Support film
- 4: Layer formed of photosensitive resin composition
- 5: Photocured layer
- 6: Cured material
- x: Width of convex portion
- y: Height of convex portion

CLAIMS

1. A photosensitive resin composition comprising a polymer (A), a glass filler (B), a photopolymerizable compound (C), and a photopolymerization initiator (D),

wherein the glass filler (B) contains at least two selected from the group consisting of silicon oxide, aluminum oxide, and boron oxide, and further contains a rare earth oxide.

2. The photosensitive resin composition according to claim 1, wherein a content of the rare earth oxide in 100 wt% of the glass filler (B) is 15 to 35 wt%.

3. The photosensitive resin composition according to claim 1 or 2, wherein a total amount of magnesium ions, calcium ions, and zinc ions detected in an extract obtained by performing an extraction treatment on the glass filler (B) under a saturated water vapor pressure condition at 121°C for 24 hours is 100 ppm or less.

4. The photosensitive resin composition according to any one of claims 1 to 3, wherein a refractive index of the glass filler (B) is 1.55 to 1.75.

5. The photosensitive resin composition according to any one

of claims 1 to 4, wherein an absolute value of a difference between a refractive index of the glass filler (B) and a refractive index of an organic component (excluding a solvent) obtained by removing the glass filler (B) from the photosensitive resin composition is 0.05 or less.

6. The photosensitive resin composition according to any one of claims 1 to 5, wherein the photopolymerizable compound (C) has one or both of an acrylic group and a glycidyl group.

7. The photosensitive resin composition according to any one of claims 1 to 6, wherein the polymer (A) includes an alkali-soluble polymer (A-1).

8. The photosensitive resin composition according to claim 7, wherein the alkali-soluble polymer (A-1) is polyimide having one or both of a phenolic hydroxyl group and a carboxyl group as an alkali-soluble group.

9. The photosensitive resin composition according to any one of claims 1 to 8, further comprising a thermal crosslinking agent (E).

10. A photosensitive resin sheet comprising at least a layer formed of the photosensitive resin composition according to any

one of claims 1 to 9 (a photosensitive resin layer) and a film that supports the layer (a support film).

11. The photosensitive resin sheet according to claim 10, wherein the support film has an oxygen permeability of 10 to 400 cc/m² and a haze of 0.1 to 1.5%.

12. The photosensitive resin sheet according to claim 10 or 11, wherein the photosensitive resin sheet is used as a wall material or a roof material for forming a hollow structure.

13. A cured material obtained by curing the photosensitive resin composition according to any one of claims 1 to 9 or the photosensitive resin layer in the photosensitive resin sheet according to any one of claims 10 to 12.

14. The cured material according to claim 13, wherein a water vapor permeability is 50 to 250 g/(m²•day).

15. A hollow structure comprising:

a substrate;

a convex portion that is formed on the substrate and is provided to surround a part of a surface of the substrate; and

a film-shaped material that is in contact with a top of the convex portion and is formed of the cured material according

to claim 13 or 14,

wherein a space (a hollow portion) closed by the substrate, the convex portion, and the film-shaped member is formed.

16. The hollow structure according to claim 15, wherein an area of the substrate in the hollow portion is 0.01 to 1.0 mm².

17. The hollow structure according to claim 15 or 16, wherein a width of the convex portion is 15 to 300 μm.

18. The hollow structure according to any one of claims 15 to 17, wherein the convex portion contains polyimide.

19. A method for producing the hollow structure according to claim 15, the method comprising the following steps 1 to 6 in this order:

step 1: a step of forming the convex portion on the substrate;

step 2: a step of bonding the photosensitive resin layer side of the photosensitive resin sheet according to any one of claims 10 to 12 to the convex portion formed on the substrate;

step 3: a step of exposing the photosensitive resin layer through the support film;

step 4: a step of peeling off the support film;

step 5: a step of developing the photosensitive resin

layer; and

step 6: a step of thermally curing the photosensitive resin layer to form a cured material.

20. An electronic component comprising the hollow structure according to any one of claims 15 to 18.

21. An elastic wave filter comprising the hollow structure according to any one of claims 15 to 18.

22. An electronic component comprising the cured material according to claim 13 or 14.