

## DESCRIPTION

## PHOTOSENSITIVE RESIN COMPOSITION

5

## TECHNICAL FIELD

[0001]

The present invention relates to a photosensitive resin composition. More particularly, the present invention relates to a photosensitive resin composition which is suitably used for surface protection films and interlayer insulating films of semiconductor elements, insulating layers of organic electroluminescent devices, and the like.

15

## BACKGROUND ART

[0002]

Heretofore, polyimide resins, polybenzoxazole resins, and the like which have excellent heat resistance, mechanical properties, and other characteristics have widely been used for surface protection films, interlayer insulating films, and the like for semiconductor elements of electronic equipment. When polyimides and polybenzoxazoles are used for surface protection films or interlayer insulating films, one of the methods of forming through holes and the like is etching using a positive type photoresist. However, this method is problematic in that the processes include applying and releasing a photoresist, causing the method to be complicated. In view of this, heat resistant materials with photosensitivity imparted thereto have been reviewed in order to streamline working processes.

[0003]

A coating film of a precursor of a polyimide or a polybenzoxazole is thermally cyclodehydrated to thereby obtain a thin film having excellent heat resistance and mechanical properties. In this case, however, a heat treatment at a high temperature of about 350°C is usually needed. However, for example, MRAM (magnetoresistive random access memory), which is promising as next generation memory, is easily affected by high temperature processes. On that account, there is a demand for polyimide resins or polybenzoxazole resins such that surface protection films formed by curing the resins by heat treatment at a low temperature of about 250°C or less achieve performance favorably comparable to that of conventional cured films formed by heat treatment at a high temperature of about 350°C.

[0004]

As methods of obtaining polyimide resins or polybenzoxazole resins cured by heat treatment at low temperature, the following methods are known: That is, addition of a ring-closing promoter; a method in which to introduce into a unit structure an organic group for promoting ring-closing at low temperature; a method in which to use a polyimide or a polybenzoxazole which is preliminarily ring-closed after having alkali-solubility imparted thereto; and the like.

[0005]

In addition, when a heat resistant resin composition is used for applications for semiconductors and the like, a cured film obtained by heat treatment remains as a permanent film in a device, which means that the properties of the cured film are very important. To secure reliability in semiconductor packages, the adhesion to a material formed on the surface of a semiconductor chip is important. In particular when a heat-resistant resin composition is used for applications such as an insulating film between wiring layers of a wafer level package, the adhesion to a metal material used for electrodes and wiring is important.

[0006]

There is a problem, however, in that a resin composition containing the resin that can be cured by heat treatment at low temperature has low adhesion to metals used as these wiring materials.

5 [0007]

It is generally considered that, because of having a rigid main chain structure, a heat resistant resin has an adhesive strength that is not high to a metal material. In particular, in a cured film of a resin composition having photosensitivity imparted thereto, the resin composition includes additives such as a photosensitizer, a  
10 sensitizer, an acid generator, and a solubility adjusting agent, which still remain in the cured film after heat-curing. Accordingly, the cured film has lower adhesive strength than the one which does not contain such additives. Examples of proposed solutions to these include: positive type photosensitive resin compositions composed of an alkali-aqueous-solution-soluble polymer, a photo acid generator, and a silane  
15 compound containing 4 or more specific functional groups bound directly to an Al atom, a Ti atom, or a Si atom (see Patent Literature 1); and heat resistant resin precursor compositions composed of a heat resistance resin precursor such as a polyimide precursor and of a specific amino compound or a thiol derivative (see  
Patent Literature 2 to 5).

20

#### Citation List

##### Patent Literature

[0008]

Patent Literature 1: JP 2008-276190 A (pages 1 to 3)

25 Patent Literature 2: JP 2007-39486 A (pages 1 to 3)

Patent Literature 3: JP 2003-5369 A (pages 1 to 3)

Patent Literature 4: WO 2014/115233 (pages 1 to 3)

Patent Literature 5: JP 2015-232688 A (pages 1 to 4)

## SUMMARY OF INVENTION

### 5 Technical Problem

[0009]

However, a photosensitive resin composition and a heat resistant resin precursor composition such as described in Patent Literature 1 to 4 pose a problem in that the resins have poor compatibility with additives and the compositions have low  
10 coatability. Because of this, the compositions applied and prebaked on rugged metal wiring may have voids generated therein, and the adhesion between the obtained cured film and the metal wiring may be lowered. In addition, the resin composition described in Patent Literature 5 may fail to produce unreacted  
15 sufficient adhesion. In view of these, an object of the present invention is to provide a photosensitive resin composition which affords a cured film having excellent adhesion to a metal material, copper among others, even through low temperature heat treatment, and has high coatability.

### 20 Solution to Problem

[0010]

To solve the above-mentioned problem, the photosensitive resin composition according to the present invention has the following structure: That is, a photosensitive resin composition containing (A) an alkali-soluble resin containing an  
25 organic group derived from an aliphatic diamine, (B) a photosensitizer, (C) a compound that is liquid under conditions of 1013 hPa and 25°C and has a boiling point of 210°C or more,

in which the photosensitive resin composition contains 0.1 to 15 parts by mass of the compound (C) that is liquid under conditions of 1013 hPa and 25°C and has a boiling point of 210°C or more with respect to 100 parts by mass of the alkali-soluble resin (A) containing an organic group derived from an aliphatic diamine.

5

#### Advantageous Effects of Invention

[0011]

The photosensitive resin composition according to the present invention has excellent coatability and can afford a cured film having excellent adhesion to a metal material, copper among others, even through low temperature heat treatment.

10

#### DESCRIPTION OF EMBODIMENTS

[0012]

The present invention is a photosensitive resin composition containing: (A) an alkali-soluble resin containing an organic group derived from an aliphatic diamine, (B) a photosensitizer, and (C) a compound that is liquid under conditions of 1013 hPa and 25°C and has a boiling point of 210°C or more, in which the photosensitive resin composition contains 0.1 to 15 parts by mass of the compound (C) that is liquid under conditions of 1013 hPa and 25°C and has a boiling point of 210°C or more with respect to 100 parts by mass of the alkali-soluble resin (A) containing an organic group derived from an aliphatic diamine. Below, the abbreviations, the component (A), the component (B), and the compound (C), may be used.

15

20

[0013]

Examples of reasons why the cured film formed by curing the photosensitive resin composition according to the present invention by heat treatment has excellent adhesion to a metal, copper among others, include the following point. That is, the

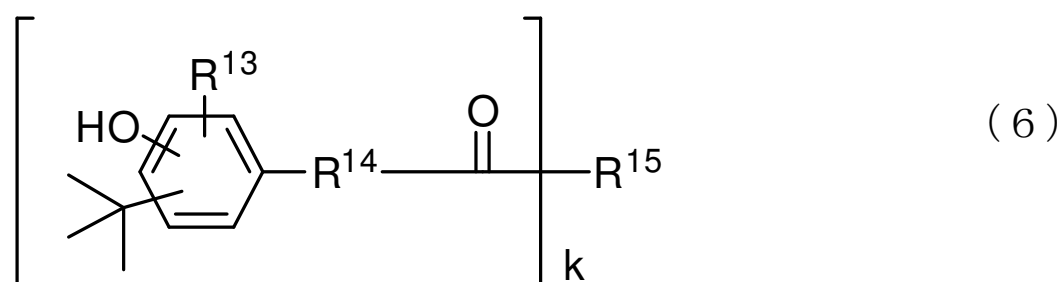
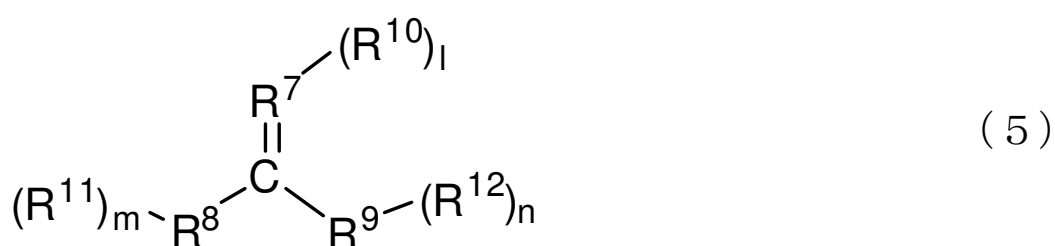
25

point is that allowing the compound (C) content to be 0.1 to 15 parts by mass with respect to 100 parts by mass of the component (A) and allowing the boiling point to be further higher makes it possible to minimize the remaining amount of the compound (C) in the cured film and makes it possible to localize the compound (C) remaining in the cured film at the boundary with a copper substrate, at which the compound (C) hardly evaporates. This locally swells and softens the portion of the cured film in the vicinity of the interface with the copper substrate. As a result, the cured film can infiltrate into the fine rugged surface of the copper substrate, and through anchor effect, the adhesion to the copper substrate is enhanced.

Furthermore, having a structure containing an amide group, in which the nitrogen atom is coordinated to copper, can enhance adhesion between the cured film and copper physically and chemically. Furthermore, allowing the photosensitive resin composition to contain (D) a compound represented by the general formula (5) and (E) a compound represented by the general formula (6) can enhance adhesion with copper.

[0014]

[Chem. 1]



[0015]

(wherein in the general formula (5),  $R^7$  to  $R^9$  represent any of an oxygen atom, sulfur atom, and nitrogen atom, and at least one of  $R^7$  to  $R^9$  represents a sulfur atom;  $l$  represents 0 or 1;  $R^7$  represents an oxygen atom or sulfur atom when  $l$  is 0 and represents a nitrogen atom when  $l$  is 1;  $m$  and  $n$  represent 1 or 2; and  $R^{10}$  to  $R^{12}$  each independently represent a hydrogen atom or a  $C_1$ - $C_{20}$  organic group.)

(wherein in the general formula (6),  $R^{13}$  represents a hydrogen atom or an alkyl group having one or more carbon atoms, and  $R^{14}$  represents an alkylene group having two or more carbon atoms;  $R^{15}$  represents a monovalent to tetravalent organic group containing at least any of an alkylene group having two or more carbon atoms, an oxygen atom, and a nitrogen atom; and  $k$  represents an integer number of 1 to 4.)

Because of this, the photosensitive resin composition according to the present invention can afford a cured film having high adhesion to a metal material, copper among others, even through low temperature heat treatment, for example, at 250°C or less.

[0016]

In addition, the photosensitive resin composition according to the present invention has excellent coatability. A photosensitive resin composition that is applied and prebaked on rugged metal wiring and that then has no void at the interface between them and has no streak generated on the coating film surface is judged to have excellent coatability. A reason why the photosensitive resin composition according to the present invention has excellent coatability is considered to be because the high boiling point of the compound (C) reduces rapid volatilization of the solvent during coating and thus can inhibit the prebaked film from having voids and streaks.

[0017]

The alkali-soluble resin (A) having an organic group derived from an aliphatic diamine used in the present invention preferably contains one or more resins selected

from polyimides, polybenzoxazole, polyamideimides, and precursor resins thereof.

[0018]

Examples of polyimide precursors preferably used in the present invention include polyamic acids, polyamic acid esters, polyamic acid amides, polyisoimides, and the like. For example, polyamic acid can be obtained by allowing a tetracarboxylic acid, the corresponding tetracarboxylic acid dianhydride, tetracarboxylic acid diester dichloride, or the like react with a diamine, the corresponding diisocyanate compound, or trimethylsilylated diamine. Polyimides can be obtained, for example, by allowing a polyamic acid obtained by the above-mentioned method to be cyclodehydrated by heat treatment or chemical treatment with an acid or a base.

[0019]

Examples of polybenzoxazole precursors preferably used in the present invention include polyhydroxyamides. For example, polyhydroxyamides can be obtained by allowing a bisaminophenol react with a dicarboxylic acid, the corresponding dicarboxylic acid chloride, dicarboxylic acid active ester, or the like. Polybenzoxazoles can be obtained, for example, by allowing a polyhydroxyamide obtained by the above-mentioned method to be cyclodehydrated by heat treatment or chemical treatment with a phosphoric acid anhydride, a base, a carbodiimide compound, or the like.

[0020]

Polyamideimide precursors preferably used in the present invention can be obtained, for example, by allowing a tricarboxylic acid, the corresponding tricarboxylic acid anhydride, tricarboxylic acid anhydride halide, or the like to react with a diamine or a diisocyanate. Polyamideimides can be obtained, for example, by allowing a precursor obtained by the above-mentioned method to be cyclodehydrated by heat treatment or chemical treatment with an acid or a base.

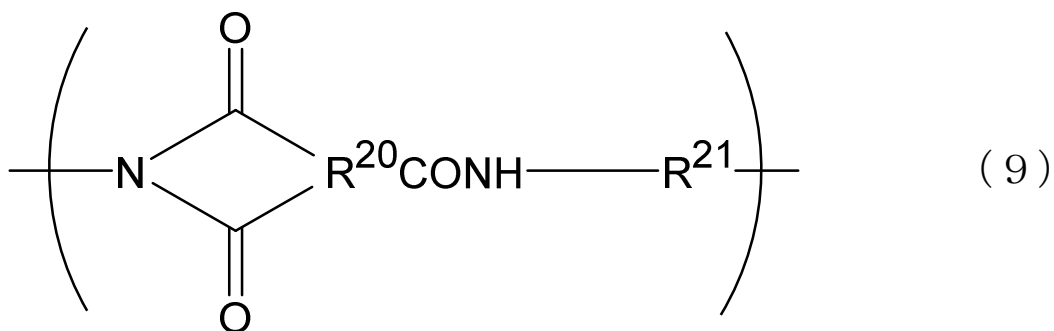
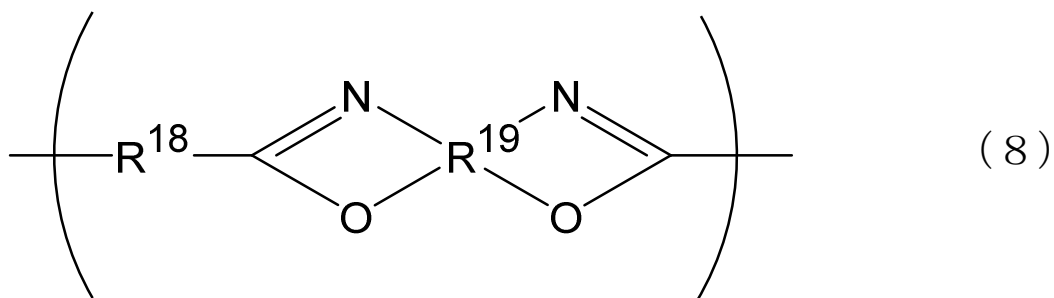
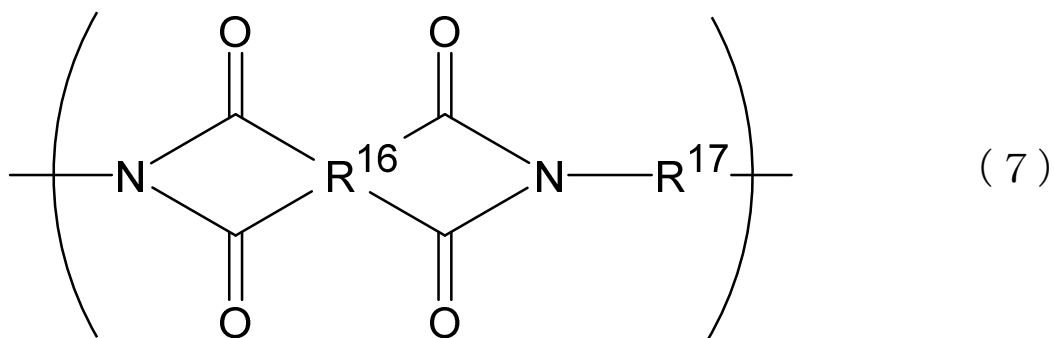
[0021]

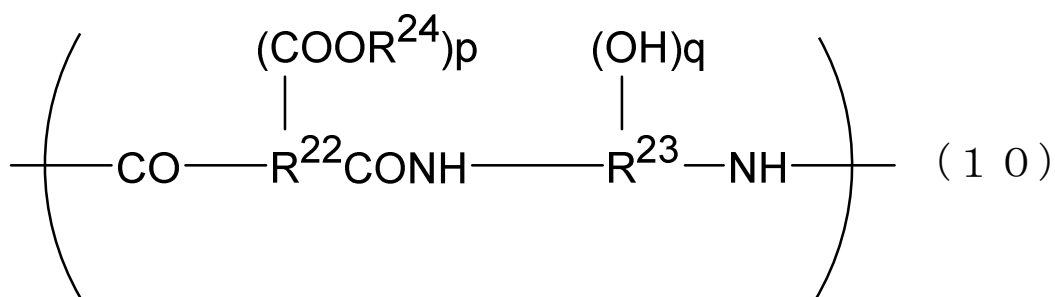
The alkali-soluble resin (A) having an organic group derived from an aliphatic diamine used in the present invention preferably has one or more selected from the structural units represented by the following general formulae (7) to (10). The

5 alkali-soluble resin (A) may be constituted by two or more resins having a structural unit such as these or may be a resin obtained by copolymerizing two or more structural units.

[0022]

[Chem. 2]





[0023]

(In the general formulae (7) to (10),  $\text{R}^{16}$  and  $\text{R}^{19}$  represent a tetravalent organic group,  $\text{R}^{17}$ ,  $\text{R}^{18}$ , and  $\text{R}^{21}$  represent a bivalent organic group,  $\text{R}^{20}$  represents a trivalent organic group,  $\text{R}^{22}$  represents a bivalent to tetravalent organic group, and  $\text{R}^{23}$  represents a bivalent to 12-valent organic group;  $\text{R}^{16}$  to  $\text{R}^{23}$  each preferably have an aromatic ring and/or aliphatic ring;  $\text{R}^{24}$  represents a hydrogen atom or a  $\text{C}_1$ - $\text{C}_{20}$  monovalent hydrocarbon group;  $p$  represents an integer number of 0 to 2; and  $q$  represents an integer number of 0 to 10.)

In the general formulae (7) to (10),  $\text{R}^{16}$  represents a tetracarboxylic acid derivative residue,  $\text{R}^{18}$  represents a dicarboxylic derivative residue,  $\text{R}^{20}$  represents a tricarboxylic acid derivative residue, and  $\text{R}^{22}$  represents a di-, tri-, or tetra- carboxylic derivative residue. As acid components constituting  $\text{R}^{16}$ ,  $\text{R}^{18}$ ,  $\text{R}^{20}$ , and  $\text{R}^{22}(\text{COOR}^{24})_p$ , examples of dicarboxylic acids include terephthalic acid, isophthalic acid, diphenyletherdicarboxylic acid, bis(carboxyphenyl)hexafluoropropane, biphenyldicarboxylic acid, benzophenonedicarboxylic acid, triphenyl dicarboxylic acid, and the like; examples of tricarboxylic acids include trimellitic acid, trimesic acid, diphenylether tricarboxylic acid, biphenyl tricarboxylic acid; and examples of tetracarboxylic acids include aromatic tetracarboxylic acids such as pyromellitic acid, 3,3',4,4'-biphenyltetracarboxylic acid, 2,3,3',4'-biphenyltetracarboxylic acid, 2,2',3,3'-biphenyltetracarboxylic acid, 3,3',4,4'-benzophenonetetracarboxylic acid, 2,2',3,3'-benzophenonetetracarboxylic acid, 2,2-bis(3,4-dicarboxyphenyl)hexafluoropropane, 2,2-bis(2,3-

dicarboxyphenyl)hexafluoropropane, 1,1-bis(3,4-dicarboxyphenyl)ethane, 1,1-bis(2,3-dicarboxyphenyl)ethane, bis(3,4-dicarboxyphenyl)methane, bis(2,3-dicarboxyphenyl)methane, bis(3,4-dicarboxyphenyl)sulfone, bis(3,4-dicarboxyphenyl)ether, 1,2,5,6-naphthalenetetracarboxylic acid, 2,3,6,7-naphthalenetetracarboxylic acid, 2,3,5,6-pyridinetetracarboxylic acid, and 3,4,9,10-  
 5 perylenetetracarboxylic acid, and aliphatic tetracarboxylic acids such as butanetetracarboxylic acid, 1,2,3,4-cyclopentanetetracarboxylic acid, and the like. One or two carboxyl groups in each of the tricarboxylic acids and tetracarboxylic acids among these correspond to the  $\text{COOR}^{24}$  group in the general formula (10).

10 These acid components can be used as they are or as acid anhydrides, active esters, or the like. Two or more kinds of these acid components may also be used in combination.

[0024]

In the general formulae (7) to (10),  $\text{R}^{17}$ ,  $\text{R}^{19}$ ,  $\text{R}^{21}$ , and  $\text{R}^{23}$  represent a diamine  
 15 derivative residue. Examples of diamine components constituting  $\text{R}^{17}$ ,  $\text{R}^{19}$ ,  $\text{R}^{21}$ , and  $\text{R}^{23}(\text{OH})_q$  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-  
 20 hydroxyphenyl)fluorene; sulfonic-acid-containing diamines such as 3-sulfonic acid-4,4'-diaminodiphenylether; thiol group-containing diamines such as dimercaptophenylenediamine; aromatic diamines such as 3,4'-diaminodiphenylether, 4,4'-diaminodiphenylether, 3,4'-diaminodiphenylmethane, 4,4'-diaminodiphenylmethane, 3,4'-diaminodiphenylsulfone, 4,4'-  
 25 diaminodiphenylsulfone, 3,4'-diaminodiphenylsulfide, 4,4'-diaminodiphenylsulfide, 1,4-bis(4-aminophenoxy)benzene, benzine, 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, 1,4-bis(4-aminophenoxy)benzene, 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, and 2,2'-bis(trifluoromethyl)-4,4'-diaminobiphenyl; or compounds each resulting from replacing some hydrogen atoms of the aromatic ring of each of the foregoing by a C<sub>1</sub>-C<sub>10</sub> alkyl group, a fluoroalkyl group, a halogen atom, or the like; alicyclic diamines such as cyclohexyldiamine and methylenebiscyclohexylamine; and the like. These diamines can be used directly or used in the form of the corresponding diisocyanate compounds or trimethylsilylated diamines. Two or more kinds of these diamine components may also be used in combination. In applications in which heat resistance is required, it is preferred to use an aromatic diamine in an amount of 50 mol% or more relative to the total amount of the diamine components.

[0025]

R<sup>16</sup> to R<sup>23</sup> in the general formulae (7) to (10) may contain a phenolic hydroxyl group, sulfonic group, thiol group, or the like in the skeleton thereof. Using a resin having a phenolic hydroxyl group, sulfonic group, or thiol group affords a photosensitive resin composition having an alkali-solubility.

[0026]

In addition, the structural units of the component (A) preferably contain a fluorine atom. The fluorine atom imparts water repellency to the surface of the film during alkali development, thus enabling permeation through the surface to be suppressed. The fluorine atom content in 100 mass% of the component (A) is preferably 10 mass% or more in order to sufficiently obtain the effect of preventing infiltration into the interface, and preferably 20 mass% or less in the light of

solubility in an aqueous alkali solution.

[0027]

The alkali-soluble resin (A) having an organic group derived from an aliphatic diamine used in the present invention preferably has the organic group derived from an aliphatic diamine in  $R^{17}$ ,  $R^{21}$ , and  $R^{23}$ . The organic group derived from an aliphatic diamine can be obtained by copolymerizing (a) an aliphatic diamine.

[0028]

The content ratio of the organic group derived from an aliphatic diamine is preferably 1 mol% or more of the whole diamine, more preferably 3 mol% or more, from the viewpoint of enhancing adhesion between the cured film and the metal. In addition, it is preferably 50 mol% or less, more preferably 40 mol% or less, from the viewpoint of enhancing heat resistance.

[0029]

Examples of the (a) aliphatic diamines include the following: That is, ethylenediamine, 1,3-diaminopropane, 2-methyl-1,3-propanediamine, 1,4-diaminobutane, 1,5-diaminopentane, 2-methyl-1,5-diaminopentane, 1,6-diaminohexane, 1,7-diaminoheptane, 1,8-diaminooctane, 1,9-diaminononane, 1,10-diaminodecane, 1,11-diaminoundecane, 1,12-diaminododecane, 1,2-cyclohexanediamine, 1,3-cyclohexanediamine, 1,4-cyclohexanediamine, 1,2-bis(aminomethyl)cyclohexane, 1,3-bis(aminomethyl)cyclohexane, 1,4-bis(aminomethyl)cyclohexane, 4,4'-methylenebis(cyclohexylamine), 4,4'-methylenebis(2-methylcyclohexylamine), bis(3-aminopropyl)tetramethyldisiloxane, and bis(p-aminophenyl)octamethylpentasiloxane; KH-511, ED-600, ED-900, ED-2003, EDR-148, EDR-176, D-200, D-400, D-2000, THF-100, THF-140, THF-170, RE-600, RE-900, RE-2000, RP-405, RP-409, RP-2005, RP-2009, RT-1000, HE-1000, HT-1100, and HT-1700 (which are tradenames and manufactured by HUNTSMAN Corporation); and the like. These compounds may contain a bond

such as -S-, -SO-, -SO<sub>2</sub>-, -NH-, -NCH<sub>3</sub>-, -N(CH<sub>2</sub>CH<sub>3</sub>)-, -N(CH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub>)-, -N(CH(CH<sub>3</sub>)<sub>2</sub>)-, -COO-, -CONH-, -OCONH-, or -NHCONH-.

[0030]

In order to enhance the storage stability of the photosensitive resin composition according to the present invention, the main chain end of the component (A) is preferably capped with an end-capping agent such as a monoamine, an acid anhydride, a monocarboxylic acid, a mono acid chloride compound, or a mono active ester compound.

[0031]

The introduction ratio of a monoamine used as an end-capping agent is preferably 0.1 mol% or more, particularly preferably 5 mol% or more, with respect to the whole amine component. In addition, it is preferably 60 mol% or less, particularly preferably 50 mol% or less.

[0032]

The introduction ratio of an acid anhydride, monocarboxylic acid, monoacid chloride compound, or monoactive ester compound used as an end-capping agent is preferably 0.1 mol% or more, particularly preferably 5 mol% or more, and preferably 100 mol% or less, particularly preferably 90 mol% or less, with respect to the diamine component. A plurality of different end groups may be introduced by reacting a plurality of end-capping agents.

[0033]

Preferred examples of monoamines include aniline, 2-ethynylaniline, 3-ethynylaniline, 4-ethynylaniline, 5-amino-8-hydroxyquinoline, 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-aminobenzenesulfonic acid, 3-aminobenzenesulfonic acid, 4-aminobenzenesulfonic acid, 3-amino-4,6-dihydroxypyrimidine, 2-aminophenol, 3-aminophenol, 4-aminophenol, 2-aminothiophenol, 3-aminothiophenol, and 4-aminothiophenol. Two or more of them may be used in combination.

[0034]

Preferred examples of acid anhydrides, monocarboxylic acids, monoacid chloride compounds, and monoactive ester compounds include acid anhydrides such as phthalic acid anhydride, maleic acid anhydride, nadic acid anhydride, cyclohexane dicarboxylic acid anhydride, and 3-hydroxyphthalic acid anhydride; monocarboxylic acids such as 3-carboxyphenol, 4-carboxyphenol, 3-carboxythiophenol, 4-carboxythiophenol, 1-hydroxy-7-carboxynaphthalene, 1-hydroxy-6-carboxynaphthalene, 1-hydroxy-5-carboxynaphthalene, 1-mercapto-7-carboxynaphthalene, 1-mercapto-6-carboxynaphthalene, 1-mercapto-5-carboxynaphthalene, 3-carboxybenzenesulfonic acid, and 4-carboxybenzenesulfonic acid; monoacid chloride compounds in which the carboxyl group of the monocarboxylic acid is formed into an acid chloride; monoacid chloride compounds in which only one carboxyl group of a dicarboxylic acid such as terephthalic acid, phthalic acid, maleic acid, cyclohexane dicarboxylic acid, 1,5-dicarboxynaphthalene, 1,6-dicarboxynaphthalene, 1,7-dicarboxynaphthalene, or 2,6-dicarboxynaphthalene is formed into an acid chloride; and active ester compounds obtained by reaction of a monoacid chloride compound with *N*-hydroxybenzotriazole and *N*-hydroxy-5-norbornene-2,3-dicarboxyimide. Two or more of them may be used in combination.

[0035]

In addition, the end-capping agent introduced into the component (A) can be

detected easily by the following methods. For example, a resin having an end-capping agent introduced thereinto is dissolved in an acidic solution to decompose the resin into an amine component and an acid anhydride component which are constituent units, and these components are subjected to measurement by gas chromatography (GC) or nuclear magnetic resonance (NMR), whereby the end-capping agent used in the present invention can be easily detected. Alternatively, a resin component having an end-capping agent introduced thereinto may also be directly subjected to measurement by pyrolysis gas chromatography (PGC), infrared spectroscopy, or  $^{13}\text{C}$ -NMR spectroscopy to detect the end-capping agent easily.

[0036]

In the component (A) used in the present invention, the number of repeats of one or more structural units selected from the structural units represented by the general formulae (7) to (10) is preferably in a range of from 3 to 1000. The number of repeats of the structural unit(s) is preferably 3 or more, which makes it possible to form a thick film easily, and preferably 1000 or less, which enables the photosensitive characteristics of the photosensitive resin composition to be maintained.

[0037]

In addition, the component (A) in the present invention may be constituted by one or more structural units alone selected from the structural units represented by the general formulae (7) to (10), or may be a copolymer or mixture thereof with another structural unit.

[0038]

With a view to enhancing the heat resistance of the obtained cured film, the content ratio of one or more structural units selected from the structural units represented by the general formulae (7) to (10) is preferably 10 mass% or more with respect to the whole component (A), more preferably 30 mass% or more, most

preferably 100 mass%.

[0039]

In a case where the structural unit is copolymerized or mixed with another structural unit, the type and amount of the structural unit used for copolymerization or mixing are preferably selected to the extent that the mechanical properties of a thin film obtained after the final heat treatment are not impaired. Examples of the main chain skeleton of the another structural unit include benzoimidazole, benzothiazol, and the like.

[0040]

The photosensitive resin composition according to the present invention contains (B) a photosensitizer. The (B) photosensitizer may be one of a negative type, which is cured by light, or one of a positive type, which is solubilized by light. As the former, (b-1) a photopolymerization initiator and a polymerizable unsaturated compound are preferably used, and as the latter, (b-2) a quinonediazide compound is preferably used.

[0041]

Examples of the photopolymerization initiator in (b-1) 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-carbonyl bis(7-diethylaminocoumarin), and 7-diethylamino-3-(1-methylbenzimidazolyl)coumarin, 3-(2-benzothiazolyl)-7-diethylaminocoumarin; anthraquinones such as 2-t-butylanthraquinone, 2-ethylanthraquinone, and 1,2-benzanthraquinone; benzoin ethers such as benzoin methylether, benzoin ethylether, and benzoin isopropyl ether; mercaptos such as ethyleneglycoldi(3-mercapto propionate),

2-mercapto benzthiazole, 2-mercapto benzoxazole, and 2-mercapto benzimidazole; glycines such as *N*-phenylglycine, *N*-methyl-*N*-phenylglycine, *N*-ethyl-*N*-(*p*-chloro phenyl)glycine, and *N*-(4-cyanophenyl)glycine; oximes such as 1-phenyl-1,2-butanedione-2-(*o*-methoxy carbonyl)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( $\alpha$ -isonitrosopropiophenoneoxime)isophthal, and 1,2-octanedione-1-[4-(phenylthio)phenyl]-2-(*o*-benzoyloxime), OXE2 (which is a tradename and manufactured by Ciba Specialty Chemicals Plc.) and NCI-831 (which is a tradename and manufactured by ADEKA Corporation);  $\alpha$ -aminoalkylphenons such as 2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)-butane-1-2-methyl-1[4-(methylthio)phenyl]-2-morpholinopropane-1-one; 2,2'-bis(*o*-chlorophenyl)-4,4',5,5'-tetraphenylbiimidazole; and the like.

[0042]

Among these, the above-mentioned oximes are preferable, and particularly preferable are 1-phenyl-1,2-propanedione-2-(*o*-ethoxycarbonyl)oxime, 1-phenyl-1,2-propanedione-2-(*o*-benzoyl)oxime, bis( $\alpha$ -isonitrosopropiophenoneoxime)isophthal, 1,2-octanedione-1-[4-(phenylthio)phenyl]-2-(*o*-benzoyloxime), OXE02, and NCI-831. These are used singly or in combination of two or more kinds thereof.

[0043]

Among these, combinations of compounds selected from the abovementioned benzophenones, glycines, mercaptos, oximes,  $\alpha$ -aminoalkylphenons, and 2,2'-bis(*o*-chlorophenyl)-4,4',5,5'-tetraphenylbiimidazole are preferred in the light of photoreaction.

[0044]

The photopolymerization initiator content in (b-1) is preferably 0.1 to 60 parts by mass, more preferably 0.2 to 40 parts by mass, with respect to the total amount of

the component (A) as 100 parts by mass. The content of 0.1 parts by mass or more is preferable in that irradiation with light generates sufficient radicals and enhances sensitivity, and the content of 60 parts by mass or less causes excessive radicals to be generated and thereby does not allow the parts unirradiated with light to be cured, enhancing the alkali developing property.

[0045]

Examples of polymerizable unsaturated compounds in (b-1) include: unsaturated double bond functional groups such as vinyl groups, allyl groups, acryloyl groups, and methacryloyl groups; and/or unsaturated triple bond functional groups such as propargyl groups; and among these, conjugate type vinyl groups, acryloyl groups, and methacryloyl groups are preferable in the light of polymerizability.

[0046]

In addition, the number of functional groups contained is preferably 1 to 4 in the light of stability, and they do not have to be the same group.

[0047]

The number average molecular weight of the polymerizable unsaturated compound in (b-1) is not limited to a particular value, and the number average molecular weight is preferably 800 or less in that it affords good compatibility with a polymer and a reactive diluent. In addition, the number average molecular weight is preferably 30 or more for the purpose of inhibiting the solubility in a developing solution after exposure.

[0048]

Specific examples of the polymerizable unsaturated compound in (b-1) include diethyleneglycoldiacrylate, triethyleneglycoldiacrylate, tetraethyleneglycoldiacrylate, diethyleneglycoldimethacrylate, triethyleneglycoldimethacrylate, tetraethyleneglycoldimethacrylate, trimethylolpropanediacrylate,

trimethylolpropanetriacrylate, trimethylolpropan dimethacrylate,  
 trimethylolpropanetrimethacrylate, styrene,  $\alpha$ -methylstyrene, 1,2-dihydronaphthalene,  
 1,3-diisopropenyl benzene, 3-methylstyrene, 4-methylstyrene, 2-vinylnaphthalene,  
 butyl acrylate, butyl methacrylate, isobutyl acrylate, hexyl acrylate, isooctyl acrylate,  
 5 isobornyl acrylate, isobornyl methacrylate, cyclohexyl methacrylate, 1,3-butanediol  
 diacrylate, 1,3-butanediol dimethacrylate, neopentylglycoldiacrylate, 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  
 10 tetraacrylate, pentaerythritol trimethacrylate, pentaerythritol tetramethacrylate,  
 dipentaerythritol hexaacrylate, dipentaerythritol hexamethacrylate, 2-  
 hydroxyethylacrylate, 2-hydroxyethylmethacrylate, 1,3-diacryloyloxy-2-  
 hydroxypropane, 1,3-dimethacryloyloxy-2-hydroxypropane, methylenebisacrylamide,  
*N,N*-dimethylacrylamide, *N*-methylol acrylamide, 2,2,6,6-tetramethylpiperidiny  
 15 methacrylate, 2,2,6,6-tetramethylpiperidiny acrylate, *N*-methyl-2,2,6,6-  
 tetramethylpiperidiny methacrylate, *N*-methyl-2,2,6,6-tetramethylpiperidiny  
 acrylate, ethylene oxide-modified bisphenol A diacrylate, ethylene oxide-modified  
 bisphenol A dimethacrylate, *N*-vinyl pyrrolidone, *N*-vinyl caprolactam, and the like.  
 These are used singly or in combination of two or more kinds thereof.

20 [0049]

Particularly preferable examples among these include 1,9-nonanediol  
 dimethacrylate, 1,10-decanediol dimethacrylate, dimethylol-tricyclodecane diacrylate,  
 isobornyl acrylate, isobornyl methacrylate, pentaerythritol triacrylate, pentaerythritol  
 tetraacrylate, pentaerythritol trimethacrylate, pentaerythritol tetramethacrylate,  
 25 dipentaerythritol hexaacrylate, dipentaerythritol hexamethacrylate,  
 methylenebisacrylamide, *N,N*-dimethylacrylamide, *N*-methylol acrylamide, 2,2,6,6-  
 tetramethylpiperidiny methacrylate, 2,2,6,6-tetramethylpiperidiny acrylate, *N*-

methyl-2,2,6,6-tetramethylpiperidinyl methacrylate, *N*-methyl-2,2,6,6-tetramethylpiperidinyl acrylate, ethylene oxide-modified bisphenol A diacrylate, ethylene oxide-modified bisphenol A dimethacrylate, *N*-vinyl pyrrolidone, *N*-vinyl caprolactam, and the like.

5 [0050]

The polymerizable unsaturated compound content in (b-1) is preferably 1 to 40 parts by mass with respect to 100 parts by mass of the component (A). It is more preferably 3 parts by mass or more for the purpose of inhibiting the solubility in a developing solution after exposure, and is more preferably 20 parts by mass or less

10 for the purpose of obtaining a highly perpendicular pattern shape.

[0051]

Examples of quinone diazide compounds in (b-2) include: a compound produced by binding quinone diazide sulfonic acid to a polyhydroxyl compound via an ester bond; a compound produced by binding quinonediazide sulfonic acid to a

15 polyamino compound via a sulfoneamide bond; and a compound produced by binding quinone diazide sulfonic acid to a polyhydroxypolyamino compound via an ester bond and/or a sulfoneamide bond. All functional groups of these polyhydroxy compound, polyamino compound, and polyhydroxypolyamino compound do not need to be substituted with quinonediazide, but, on the average, 40 mol% or more of

20 the whole functional groups are preferably substituted with quinonediazide. By using such a quinonediazide compound, a positive type photosensitive resin composition which is photosensitive to the i-line (wavelength of 365 nm), h-line (wavelength of 405 nm), and g-line (wavelength of 436 nm) of a mercury lamp, which are common ultraviolet rays, can be obtained.

25 [0052]

Examples of the polyhydroxy compound include, but are not limited to, Bis-Z, BisP-EZ, TekP-4HBPA, TrisP-HAP, TrisP-PA, TrisP-SA, TrisOCR-PA, BisOCHP-

Z, BisP-MZ, BisP-PZ, BisP-IPZ, BisOCP-IPZ, BisP-CP, BisRS-2P, BisRS-3P, BisP-OCHP, methylenetris-FR-CR, BisRS-26X, DML-MBPC, DML-MBOC, DML-OCHP, DML-PCHP, DML-PC, DML-PTBP, DML-34X, DML-EP, DML-POP, dimethylol-BisOC-P, DML-PFP, DML-PSBP, DML-MTrisPC, TriML-P, TriML-35XL, TML-BP, TML-HQ, TML-pp-BPF, TML-BPA, TMOM-BP, HML-TPPHBA, HML-TPHAP (which are tradenames, manufactured by Honshu Chemical Industry Co., Ltd.), BIR-OC, BIP-PC, BIR-PC, BIR-PTBP, BIR-PCHP, BIP-BIOC-F, 4PC, BIR-BIPC-F, TEP-BIP-A, 46DMOC, 46DMOEP, TM-BIP-A (which are tradenames, manufactured by ASAHI ORGANIC CHEMICALS INDUSTRY CO., LTD.), 2,6-dimethoxymethyl-4-t-butylphenol, 2,6-dimethoxymethyl-p-cresol, 2,6-diacetoxymethyl-p-cresol, naphthol, tetrahydroxybenzophenone, gallic acid methyl ester, bisphenol A, bisphenol E, methylenebisphenol, BisP-AP (tradename, manufactured by Honshu Chemical Industry Co., Ltd.), novolac resin, and the like.

[0053]

Examples of polyamino compounds include, but are not limited to, 1,4-phenylenediamine, 1,3-phenylenediamine, 4,4'-diaminodiphenylether, 4,4'-diaminodiphenylmethane, 4,4'-diaminodiphenylsulfone, 4,4'-diaminodiphenylsulfide, and the like.

[0054]

Examples of polyhydroxypolyamino compounds include, but are not limited to, 2,2-bis(3-amino-4-hydroxyphenyl)hexafluoropropane, 3,3'-dihydroxybenzidine, and the like.

[0055]

It is more preferable that, among these, the (b-2) quinonediazide compound contains an ester of a phenol compound and a 5-naphthoquinonediazidesulfonyl group or a 4-naphthoquinonediazidesulfonyl group. Thus, high sensitivity and high resolution can be obtained by i-line exposure.

[0056]

The (b-2) quinonediazide compound content is preferably 20 parts by mass or more, more preferably 40 parts by mass or more, with respect to 100 parts by mass of the component (A) for the purpose of enhancing pattern contrast. In addition, it is  
5 preferably 200 parts by mass or less, more preferably 150 parts by mass or less, for the purpose of enhancing sensitivity and reducing the required exposure energy. Furthermore, a sensitizer may be optionally added.

[0057]

The photosensitive resin composition according to the present invention  
10 contains (C) a compound that is liquid under conditions of 1013 hPa and 25°C and has a boiling point of 210°C or more. Allowing the compound (C) to be contained in an amount of 0.1 to 15 parts by mass with respect to 100 parts by mass of the component (A) and further to have a high boiling point makes it possible to minimize the remaining amount of the compound (C) in the cured film. The remaining  
15 compound (C) has a higher concentration at the boundary with a copper substrate, which evaporates the compound (C) less easily. This swells the cured film locally in the vicinity of the interface with the copper substrate and softens the cured film. This enables the cured film to infiltrate into the fine rugged surface of the copper substrate, and through anchor effect, the adhesion to the copper substrate is enhanced.  
20 Furthermore, the total compound (C) content in the cured film obtained by curing the photosensitive resin composition according to the present invention is preferably 0.005 mass% or more, more preferably 0.05 mass% or more, and preferably 5 mass% or less, more preferably 3 mass% or less, with respect to the total mass of the cured film. The total compound (C) content of 0.005 mass% or more can enhance  
25 adhesion to a copper substrate, and 3 mass% or less enables the compound itself to be discharged so as not to reduce reliability.

[0058]

A reason why the coatability is excellent is because the high boiling point of the compound (C) suppresses rapid volatilization during coating and thus affords coatability even on rugged metal wiring without causing voids.

[0059]

5       The compound (C) is preferably has a boiling point of 210°C or more with a view to making it more likely that the compound (C) remains in the film after heat treatment. In addition, the boiling point is preferably 400°C or less in the light of the process time for prebaking and the developing property of the prebaked film. In a case where no boiling point measurement can be made at normal pressure, boiling  
10       point conversions for normal pressure can be made in accordance with the boiling point conversion table in the general catalog 2008-2009 (No.39), p.2173, of Tokyo Chemical Industry Co., Ltd. (adapted from Science and Petroleum, Vol. II. p.1281 (1938)).

[0060]

15       The mass% of the compound (C) in the cured film can be determined by measuring the mass of the compound in a sampled cured film using a purge and trap method, a TPD-MS method, or the like, calculating the value from the specific gravity of the alkali-soluble resin (a) component, and calculating the mass% of the compound (C) in the cured film.

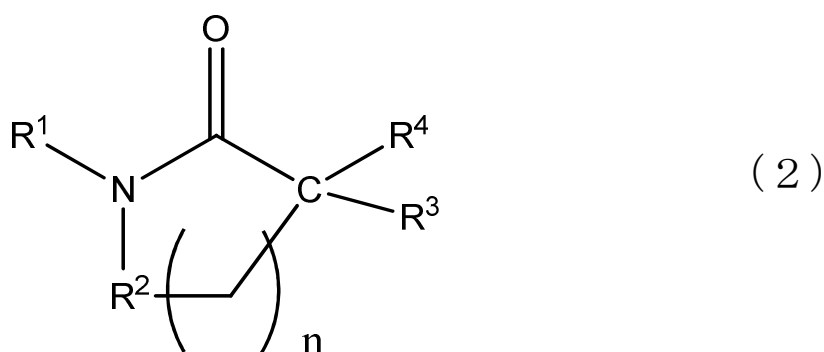
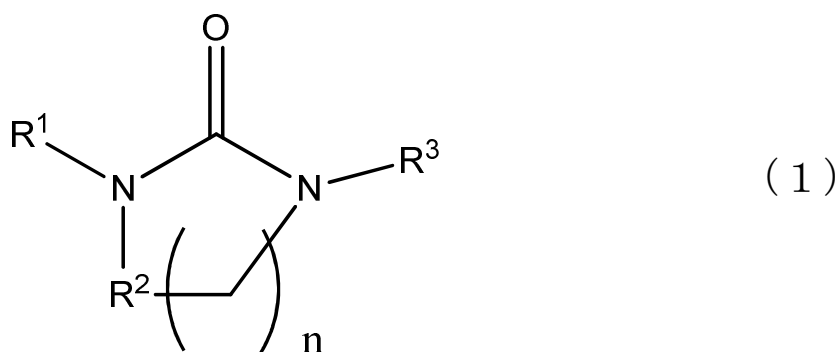
20       [0061]

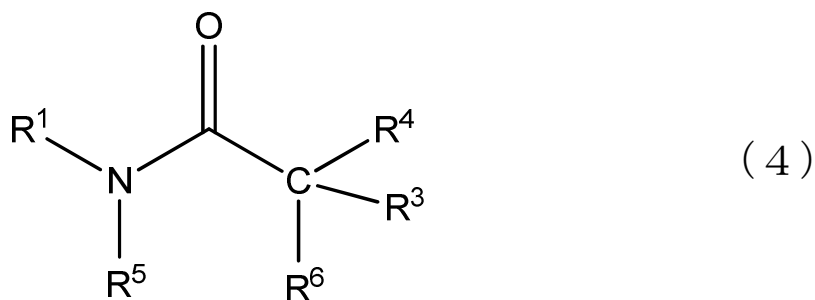
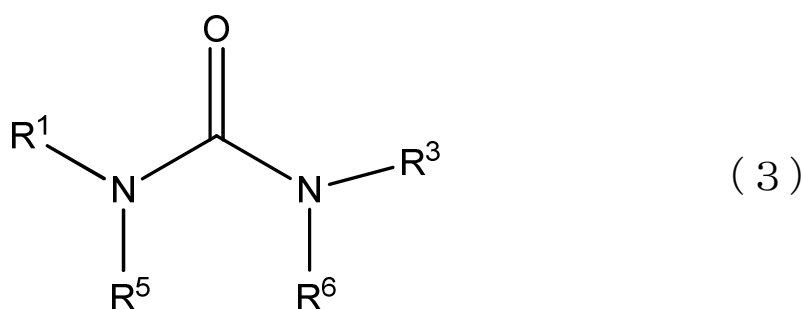
Specific example of the compound (C) include 1,3-dimethyl-2-imidazolidinone (boiling point: 220°C), *N,N*-dimethylpropyleneurea (boiling point: 246°C), 3-methoxy-*N,N*-dimethylpropionamide (boiling point: 216°C), 3-butoxy-*N,N*-dimethylpropionamide (boiling point: 252°C), delta-valerolactone (boiling point:  
25       230°C), 2-phenoxyethanol (boiling point: 245°C), 2-pyrrolidone (boiling point: 245°C), 2-methyl-1,3-propanediol (boiling point: 213°C), diethyleneglycolbutyl ether (boiling point: 230°C), triacetin (boiling point: 260°C), butylbenzoate (boiling

point: 250°C), cyclohexylbenzene (236°C), bicyclohexyl (239°C), o-nitroanisole (273°C), diethyleneglycolmonobutyl ether (230°C), triethyleneglycolmonomethylether (248°C), 3-methoxy-*N,N*-dimethylpropionamide (boiling point: 216°C), *N*-cyclohexyl-2-pyrrolidone (boiling point: 154°C/7 mmHg, 305°C in terms of the boiling point at normal pressure), *N*-(2-hydroxyethyl)-2-pyrrolidone (boiling point :175°C/10 mmHg, 313°C in terms of the boiling point at normal pressure), and the like. Among these, the compound (C) is preferably any of those which have a structure represented by the following general formulae (1) to (4), in the light of adhesion to copper.

10 [0062]

[Chem. 3]





[0063]

(In the general formulae (1) to (4), R<sup>1</sup> represents hydrogen or a C<sub>1</sub>-C<sub>5</sub> alkyl group; R<sup>2</sup> represents a C<sub>1</sub>-C<sub>5</sub> bivalent organic group; R<sup>5</sup> represents hydrogen or a C<sub>1</sub>-C<sub>5</sub> organic group; R<sup>3</sup>, R<sup>4</sup>, and R<sup>6</sup> independently represent a C<sub>1</sub>-C<sub>5</sub> organic group; and n represents an integer number of 1 to 3.)

In addition, two or more of the compound (C)s may be contained, and the compound (C) may be used as a polymerization solvent for the component (A).

[0064]

In a case where the compound (C) is used as a polymerization solvent for the component (A), the compound (C) is precipitated again in a poor solvent such as pure water after completion of the polymerization reaction, washed, purified, and dried, whereby a prescribed amount of the compound (C) can be contained in the photosensitive resin composition according to the present invention.

[0065]

The compound (C) content is preferably 0.1 parts by mass or more, more preferably 0.5 parts by mass or more, and preferably 15 parts by mass or less, more preferably 10 parts by mass or less, with respect to 100 parts by mass of the

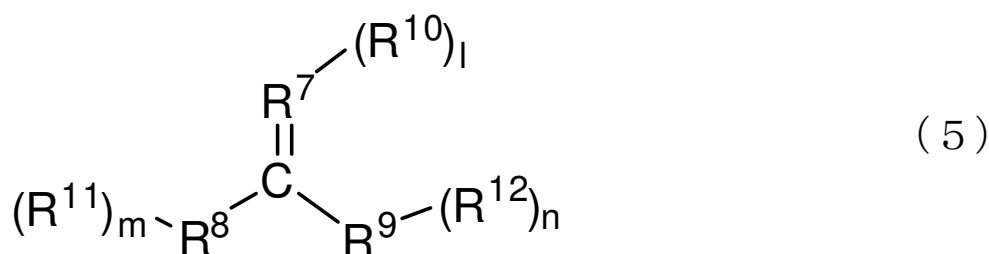
component (A) resin. The content of 0.1 parts by mass or more can enhance adhesion to copper, and 15 parts by mass or less can afford a desired patterned film made as a developed film.

[0066]

The photosensitive resin composition according to the present invention preferably contains (D) a compound represented by the general formula (5) (hereinafter, may be referred to as the component (D) for short). Containing the component (D) remarkably enhances adhesion between a film obtained after heat-curing and a metal material, copper among others. This is due to the fact that the sulfur atom and nitrogen atom of the compound represented by the general formula (5) interact with a metal surface efficiently and, in addition, due to the fact that the compound has a stereo structure which interacts more readily with the metal surface. These effects enable the photosensitive resin composition according to the present invention to afford a cured film having excellent adhesion to a metal material. The component (D) is a compound that interacts with copper among others, and containing the compound significantly enhances adhesion between a film cured by heating and a metal material.

[0067]

[Chem. 4]



[0068]

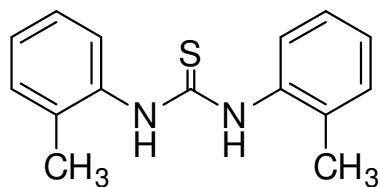
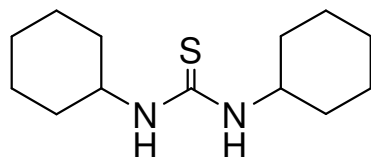
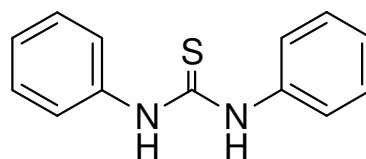
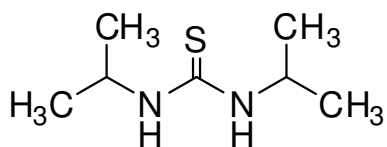
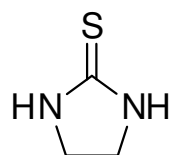
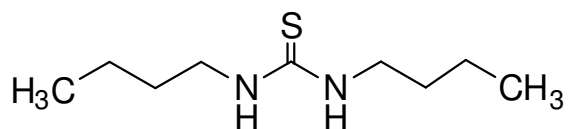
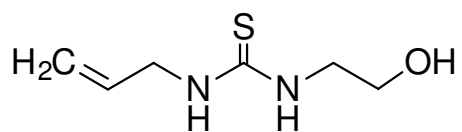
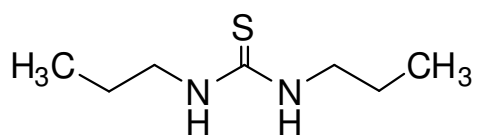
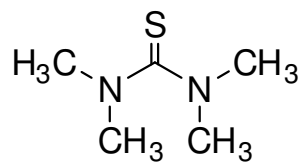
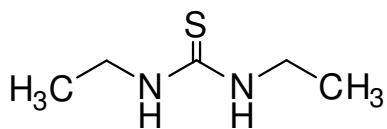
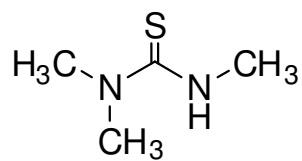
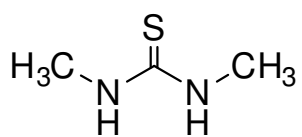
(In the general formula (5),  $\text{R}^7$  to  $\text{R}^9$  represent any of an oxygen atom, sulfur atom, or nitrogen atom, and at least one of  $\text{R}^7$  to  $\text{R}^9$  represents a sulfur atom;  $l$  represents 0 or 1;  $\text{R}^7$  represents an oxygen atom or sulfur atom when  $l$  is 0 and

represents a nitrogen atom when l is 1; m and n represent 1 or 2;  $R^{10}$  to  $R^{12}$  independently represent a hydrogen atom or a  $C_1$ - $C_{20}$  organic group; and examples of  $R^{10}$  to  $R^{12}$  include a hydrogen atom, alkyl groups, cycloalkyl groups, alkoxy groups, alkyl ether groups, alkylsilyl groups, alkoxysilyl groups, aryl groups, aryl ether groups, carboxyl groups, carbonyl groups, allyl groups, vinyl groups, heterocyclic groups, combinations thereof, and the like, and  $R^{10}$  to  $R^{12}$  may further contain a substituent.)

Examples of compounds represented by the general formula (5) include, but are not limited to, the following structures:

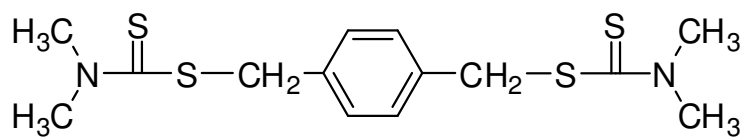
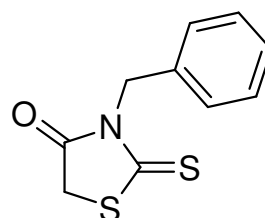
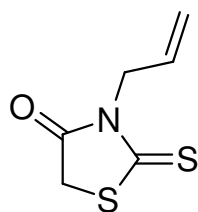
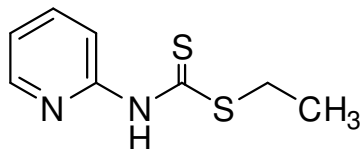
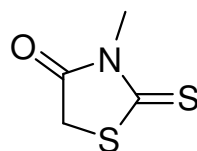
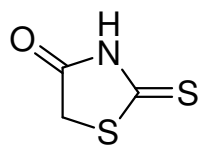
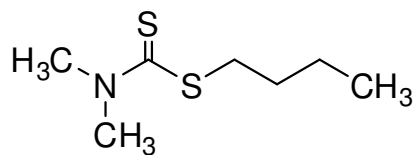
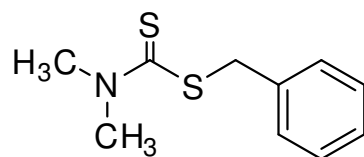
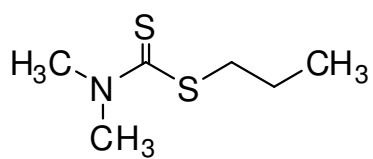
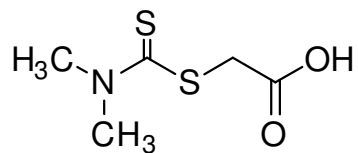
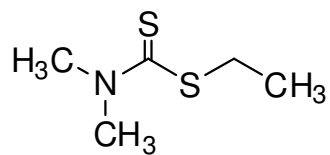
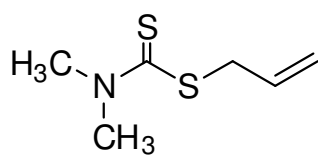
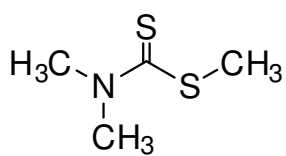
[0069]

[Chem. 5]



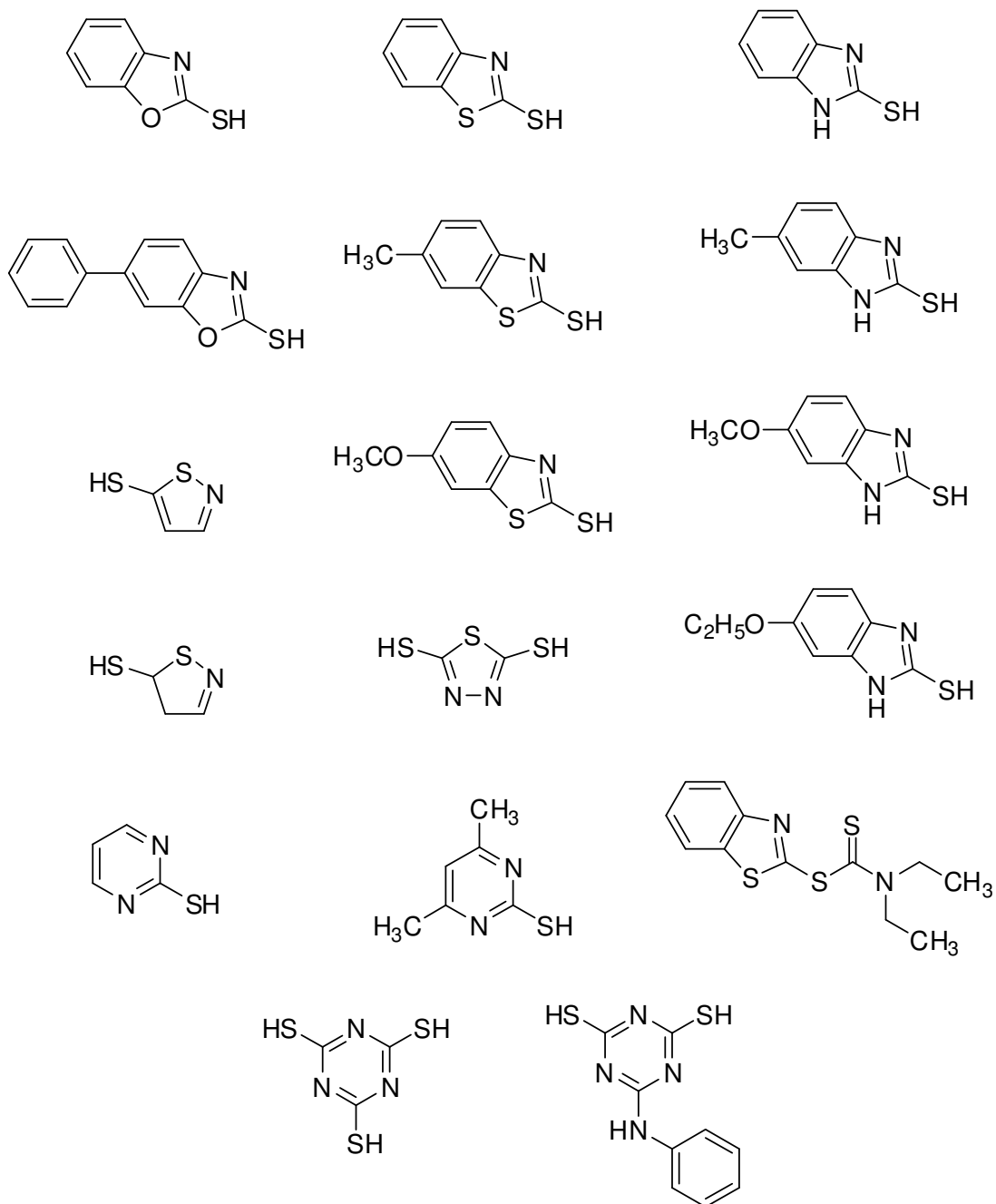
[0070]

[Chem. 6]



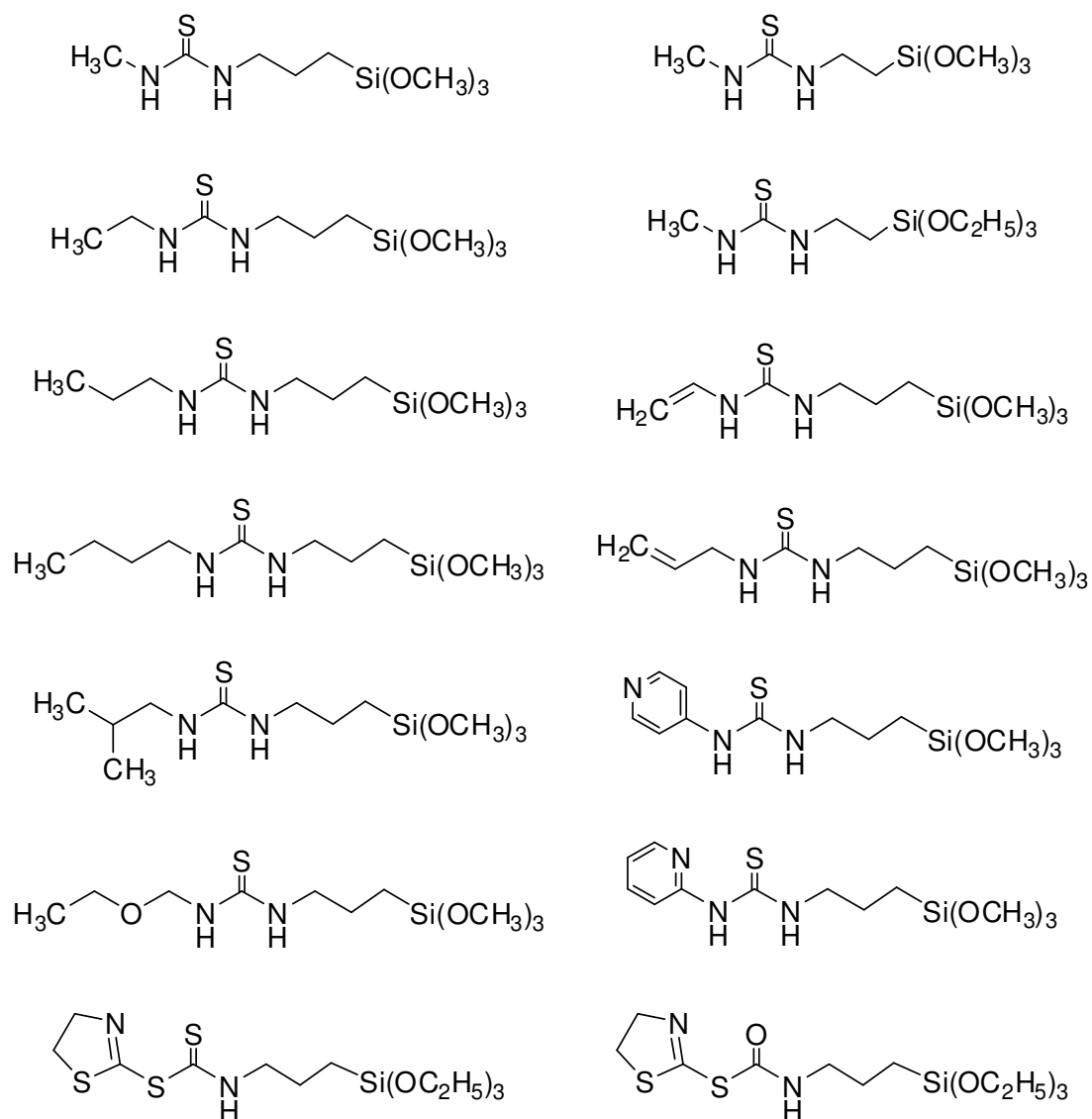
[0071]

[Chem. 7]



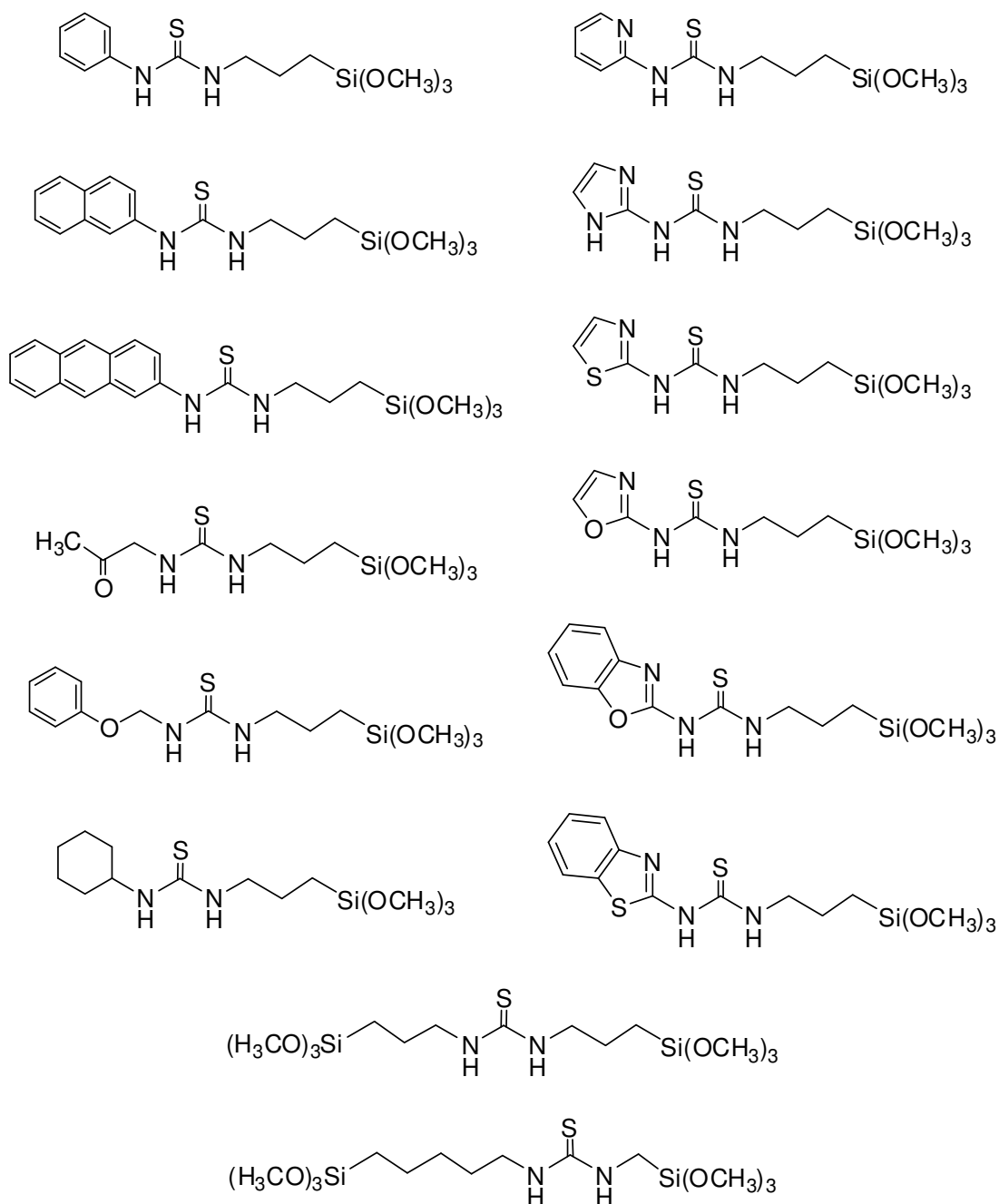
[0072]

[Chem. 8]



[0073]

[Chem. 9]



[0074]

The amount of (D) a compound represented by the general formula (5) is preferably 1 to 40 parts by mass with respect to 100 parts by mass of the component

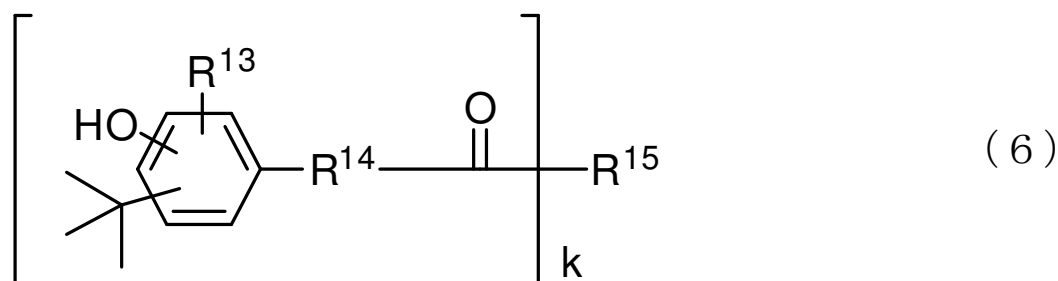
5 (A), more preferably 3 parts by mass or more, for the purpose of inhibiting the solubility in a developing solution after exposure, and more preferably 20 parts by mass or less in the light of storage stability.

[0075]

The photosensitive resin composition according to the present invention preferably contains (E) a compound represented by the following general formula (6) (hereinafter, may be referred to as the component (E) for short). Containing the component (E) can suppress reduction in the mechanical properties of a cured film obtained after reliability evaluation and suppress reduction in the adhesion to a metal material.

[0076]

[Chem. 10]



[0077]

(In the general formula (6),  $R^{13}$  represents a hydrogen atom or an alkyl group having one or more carbon atoms, and  $R^{14}$  represents an alkylene group having two or more carbon atoms;  $R^{15}$  represents a monovalent to tetravalent organic group containing at least any of an alkylene group having two or more carbon atoms, an oxygen atom, and a nitrogen atom; and  $k$  represents an integer number of 1 to 4.)

The component (E) acts as an antioxidant, thereby suppressing the oxidation degradation of the aliphatic group and phenolic hydroxyl group of the component (A). In addition, the anti-corrosive action on a metal material can suppress the oxidation of the metal material.

[0078]

In addition, the component (E) in the cured film interacts with both the component (A) and the metal material in the cured film, thereby enabling the adhesion between the cured film and the metal material to be enhanced. In order

for the component (E) to interact with both the component (A) and the metal material in the cured film more efficiently, k is more preferably an integer number of 2 to 4.

Examples of R<sup>15</sup> include alkyl groups, cycloalkyl groups, aryl groups, aryl ether groups, carboxyl groups, carbonyl groups, allyl groups, vinyl groups, heterocyclic groups, -O-, -NH-, -NHNH-, and combinations thereof, and the like, and R<sup>15</sup> may further contain a substituent. Among these, an alkyl ether and -NH- are preferably contained in the light of the solubility in a developing solution and the adhesion to metal, and -NH- is more preferable in the light of the adhesion to metal due to the interaction with the component (A) and to the metal complex formation.

[0079]

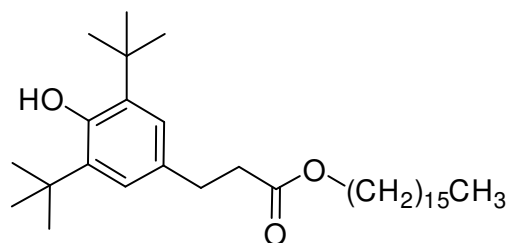
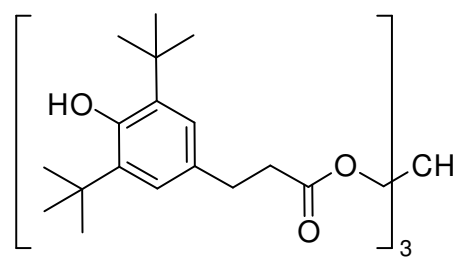
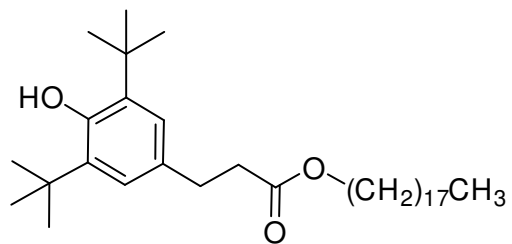
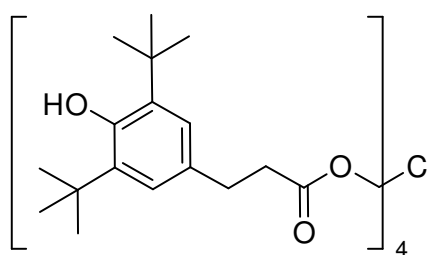
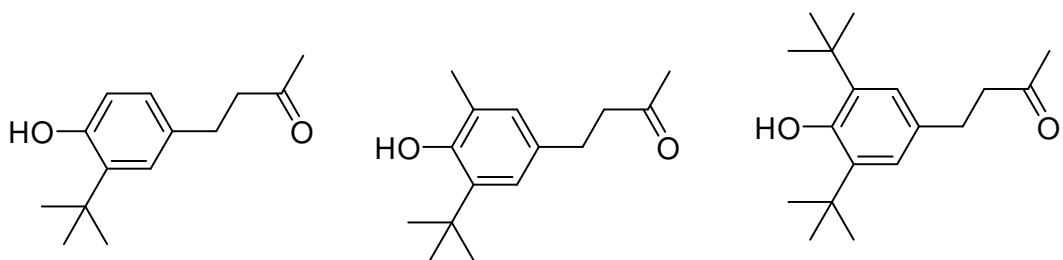
The addition amount of the component (E) is preferably 0.1 to 10 parts by mass, more preferably 0.5 to 5 parts by mass, with respect to 100 parts by mass of the component (A). The 0.1 parts by mass or more addition amount is preferable in that it can suppress the oxidation degradation of the aliphatic group and the phenolic hydroxyl group and that the anti-corrosive action on a metal material can suppress the oxidation of the metal material. In addition, the 10 parts by mass or less addition amount is preferable in that the interaction with the photosensitizer can suppress reduction in the sensitivity of the positive type photosensitive resin composition obtained before curing.

[0080]

Examples of the component (E) include, but are not limited to, the following structures:

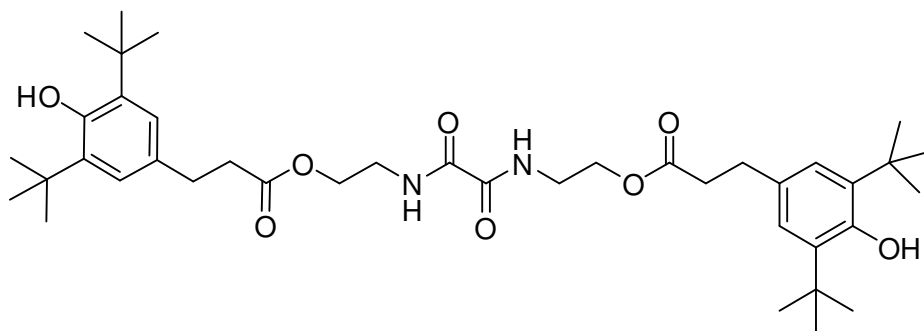
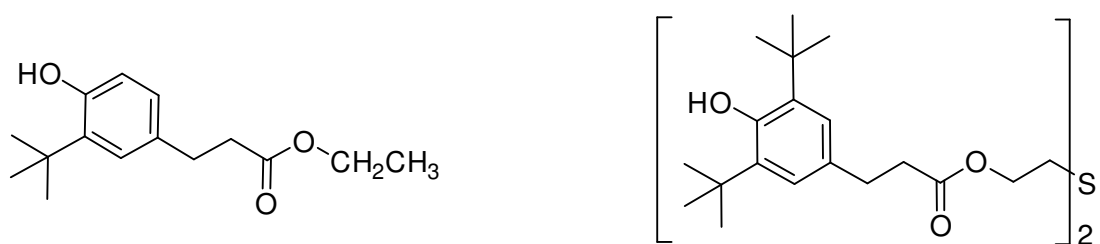
[0081]

[Chem. 11]



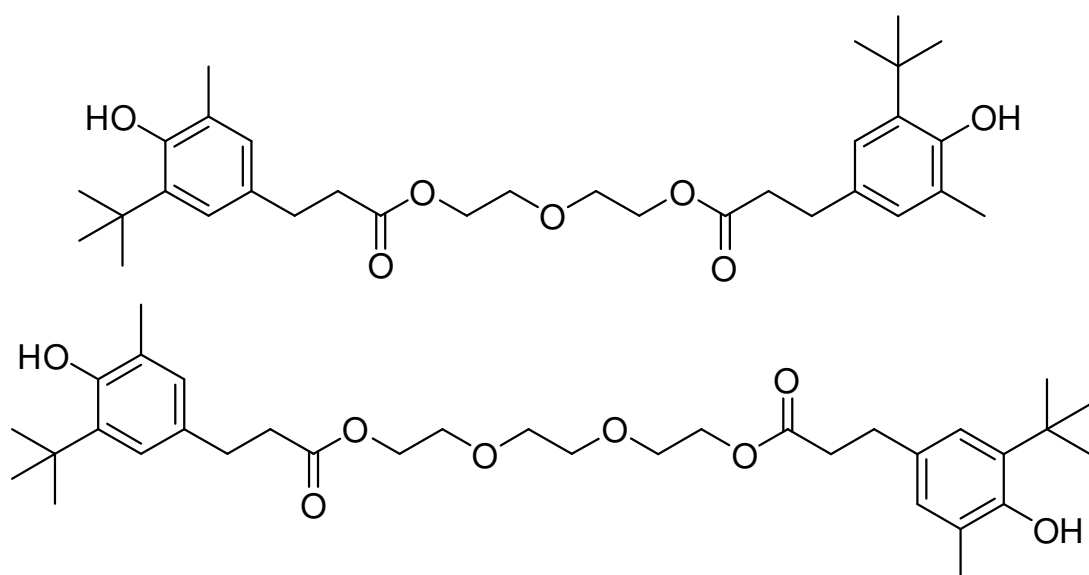
[0082]

[Chem. 12]



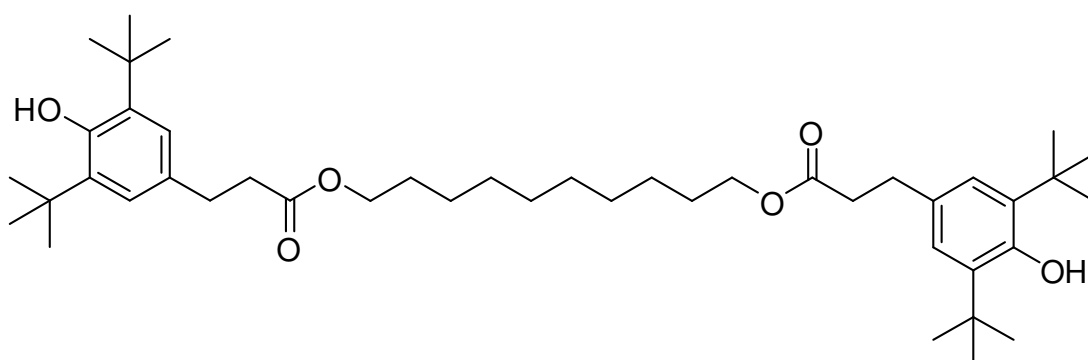
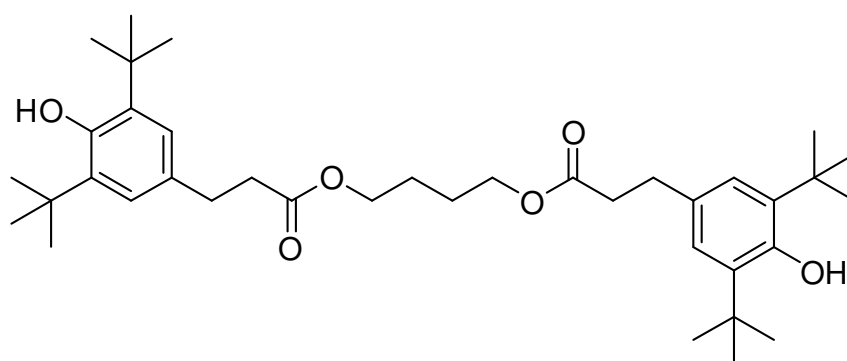
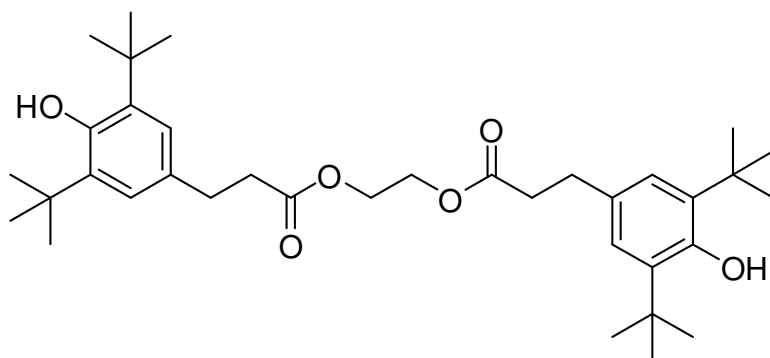
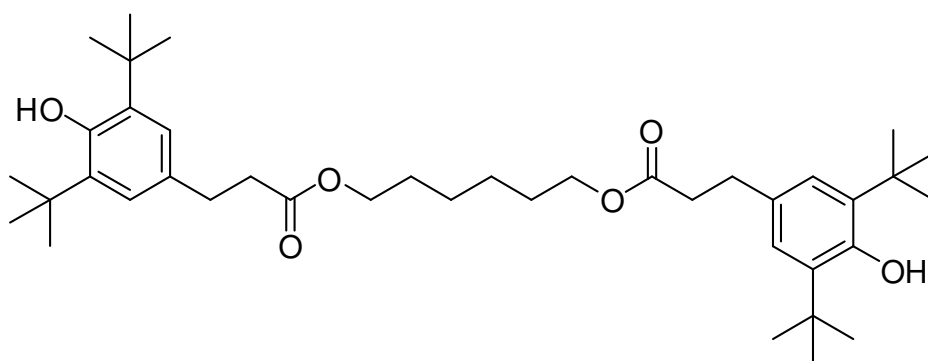
5 [0083]

[Chem. 13]



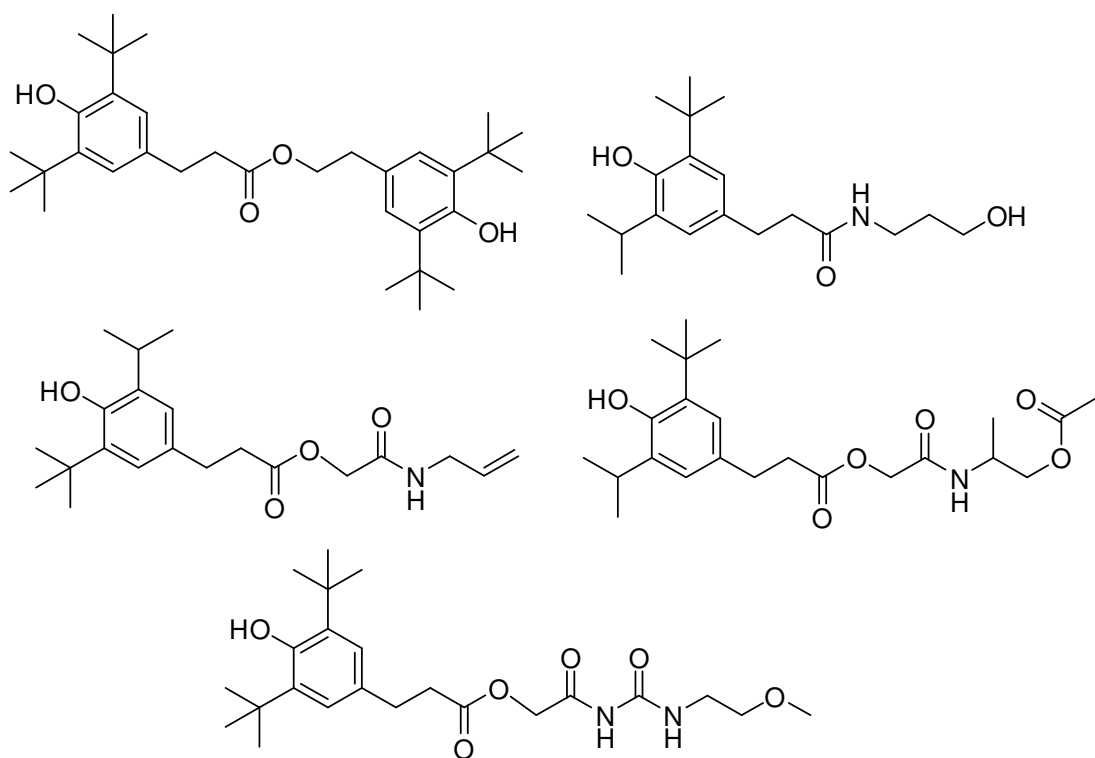
[0084]

[Chem. 14]



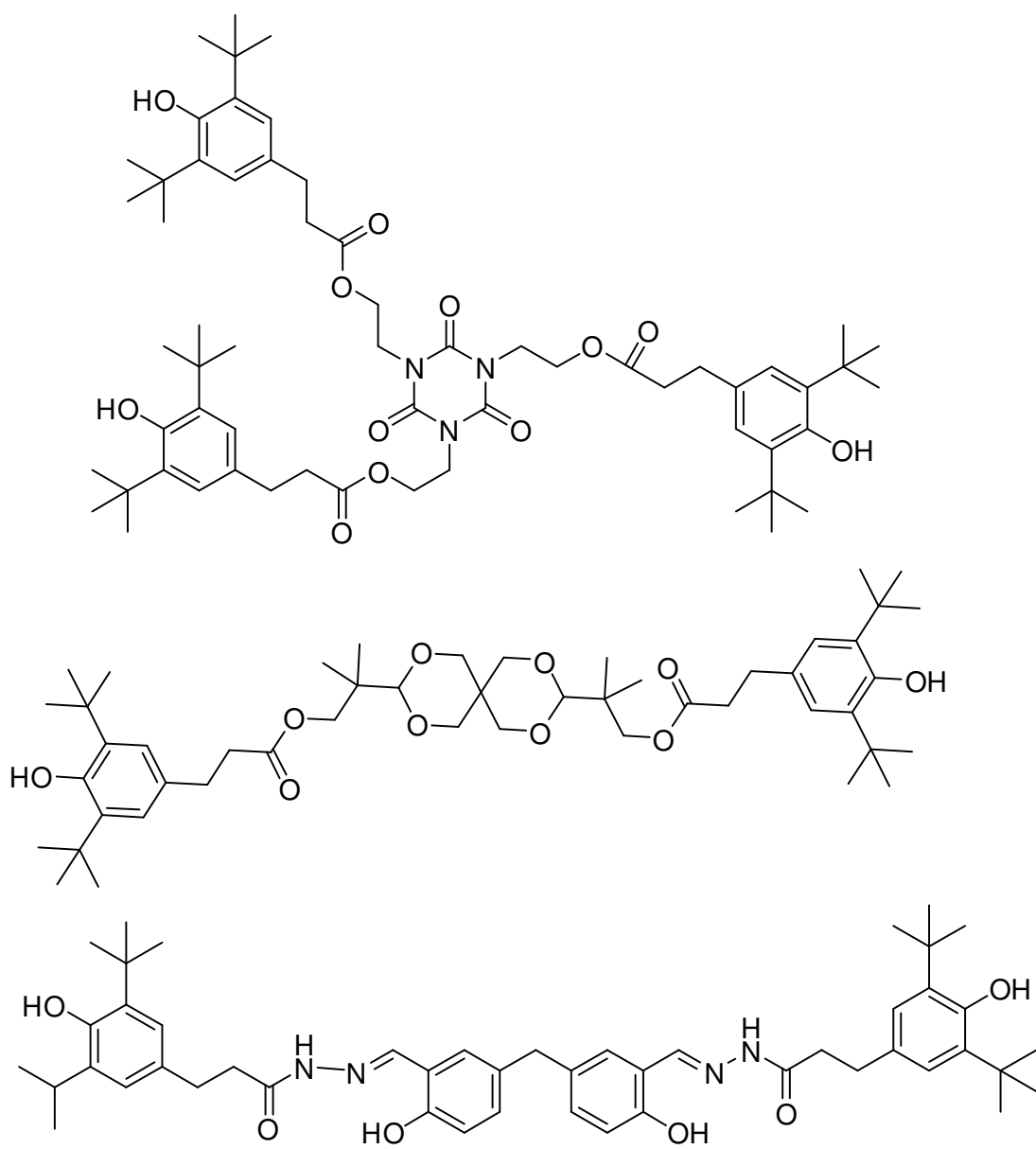
[0085]

[Chem. 15]



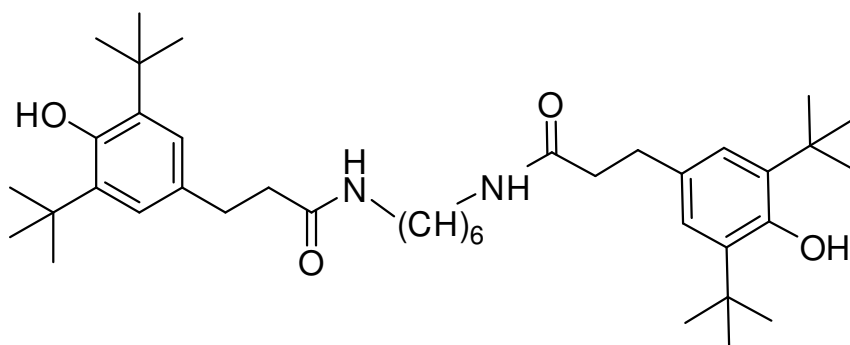
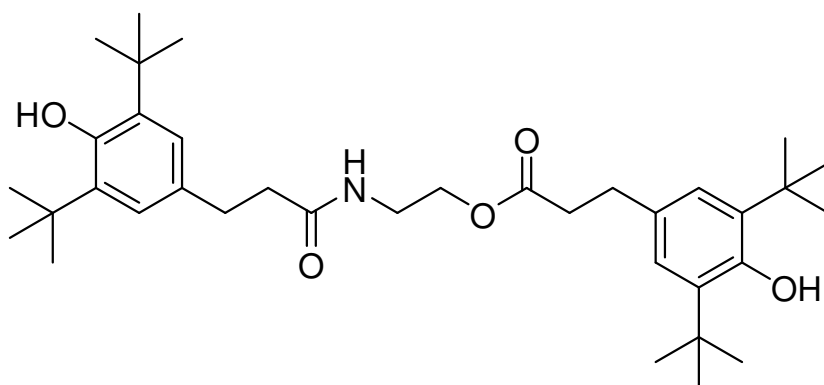
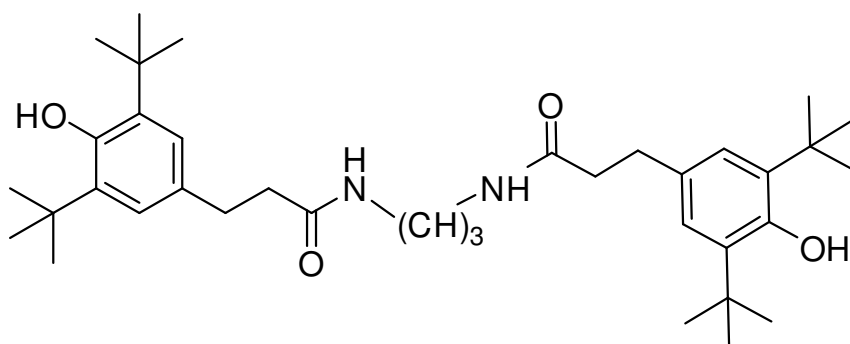
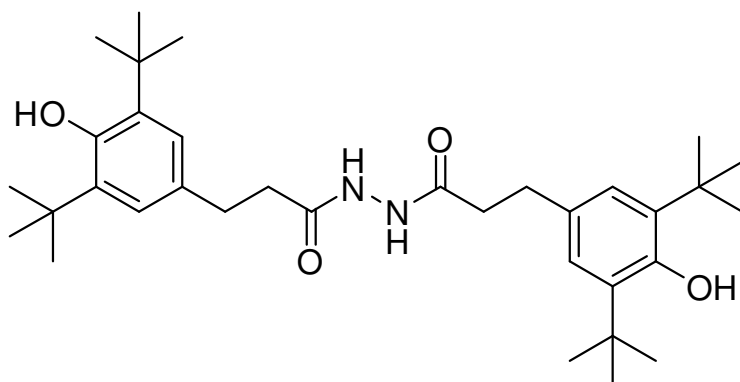
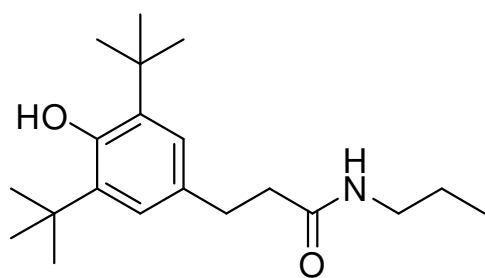
[0086]

[Chem. 16]



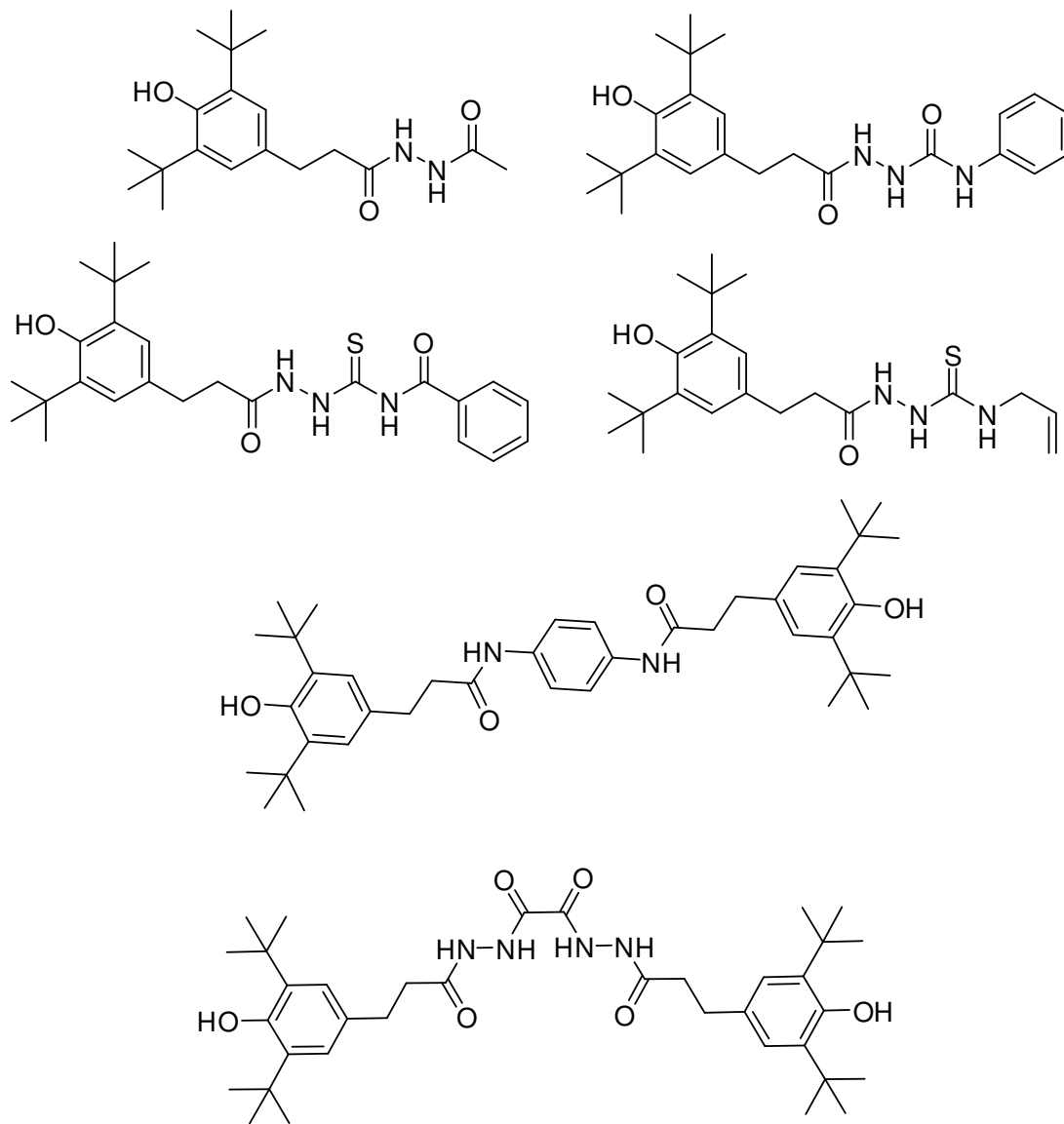
[0087]

[Chem. 17]



[0088]

[Chem. 18]



[0089]

- 5           The photosensitive resin composition according to the present invention may contain a solvent, if necessary. Preferable examples of solvents include: polar aprotic solvents such as *N*-methyl-2-pyrrolidone,  $\gamma$ -butyrolactone, *N,N*-dimethylformamide, *N,N*-dimethylacetamide, and dimethylsulfoxide; ethers such as tetrahydrofuran, dioxane, propyleneglycolmonomethylether, and
- 10          propyleneglycolmonoethylether; ketones such as acetone, methylethylketone, and

diisobutylketone; esters such as ethylacetate, butylacetate, isobutylacetate, propylacetate, propyleneglycolmonomethyletheracetate, and 3-methyl-3-methoxybutylacetate; alcohols such as ethyllactate, methyllactate, diacetonealcohol, and 3-methyl-3-methoxybutanol; aromatic hydrocarbons such as toluene and xylene; and the like. The photosensitive resin composition may contain two or more kinds of these.

[0090]

The solvent content is preferably 70 parts by mass or more, more preferably 100 parts by mass or more, with a view to enhancing the solubility of a resin, and preferably 1800 parts by mass or less, more preferably 1500 parts by mass or less, with a view to obtaining a suitable film thickness, with respect to 100 parts by mass of the component (A).

[0091]

The photosensitive resin composition according to the present invention may contain, if necessary, a low molecular weight compound having a phenolic hydroxyl group to the extent that a shrinkage residual film rate obtained after curing is not reduced. Containing a low molecular weight compound having a phenolic hydroxyl group makes it easier to regulate the alkali solubility during patterning.

[0092]

The amount of the low molecular weight compound that has a phenolic hydroxyl group and that is preferable for the purpose of expressing the above-mentioned effect is preferably 0.1 parts by mass or more, more preferably 1 part by mass or more, with respect to 100 parts by mass of the component (A), and preferably 30 parts by mass or less, more preferably 15 parts by mass or less, with a view to maintaining mechanical properties such as elongation.

[0093]

The photosensitive resin composition according to the present invention may

contain a heat-crosslinker, if necessary. Examples of heat-crosslinkers that are preferably used include, but are not limited to: compounds having at least two of alkoxymethyl groups and/or methylol groups; and compounds having at least two of epoxy groups and/or oxetanyl groups. Containing these compounds induces a  
 5 condensation reaction with the component (A) during curing after patterning and thus affords a cross-linked structure, thereby enhancing the mechanical properties of the cured film, such as elongation. In addition, two or more heat-crosslinkers may be used, and this allows wider designing.

[0094]

10       Preferable examples of compounds having at least two of alkoxymethyl groups and/or methylol groups include: DML-PC, DML-PEP, DML-OC, DML-OEP, DML-34X, DML-PTBP, DML-PCHP, DML-OCHP, DML-PFP, DML-PSBP, DML-POP, DML-MBOC, DML-MBPC, DML-MTrisPC, DML-BisOC-Z, DML-BisOCHP-Z, DML-BPC, DML-BisOC-P, DMOM-PC, DMOM-PTBP, DMOM-MBPC, TriML-P,  
 15 TriML-35XL, TML-HQ, TML-BP, TML-pp-BPF, TML-BPE, TML-BPA, TML-BPAF, TML-BPAP, TMOM-BP, TMOM-BPE, TMOM-BPA, TMOM-BPAF, TMOM-BPAP, HML-TPPHBA, HML-TPHAP, HMOM-TPPHBA, and HMOM-TPHAP (which are tradenames and manufactured by Honshu Chemical Industry Co., Ltd.); “NIKALAC” (registered trademark) MX-290, NIKALAC MX-280,  
 20 NIKALAC MX-270, NIKALAC MX-279, NIKALAC MW-100LM, and NIKALAC MX-750LM (which are tradenames and manufactured by Sanwa Chemical Co., Ltd.); and the products are available from the respective companies. The photosensitive resin composition may contain two or more kinds of these.

[0095]

25       Preferable examples of compounds having at least two of epoxy groups and/or oxetanyl groups include, but are not limited to, bisphenol A epoxy resins, bisphenol A oxetanyl resins, bisphenol F epoxy resins, bisphenol F oxetanyl resins,

propyleneglycoldiglycidyl ether, polypropyleneglycoldiglycidyl ether, and epoxy-group-containing silicones such as polymethyl(glycidyloxypropyl)siloxane; and the like.

[0096]

5           Specific examples include “EPICLON” (registered trademark) 850-S, EPICLON HP-4032, EPICLON HP-7200, EPICLON HP-820, EPICLON HP-4700, EPICLON EXA-4710, EPICLON HP-4770, EPICLON EXA-859CRP, EPICLON EXA-1514, EPICLON EXA-4880, EPICLON EXA-4850-150, EPICLON EXA-4850-1000, EPICLON EXA-4816, and EPICLON EXA-4822 (which are tradenames  
10           and manufactured by DIC Corporation); “RIKARESIN” (registered trademark) BEO-60E (which is a tradename and manufactured by New Japan Chemical Co., Ltd.); EP-4003S and EP-4000S (which are tradenames and manufactured by ADEKA Corporation); and the products are available from the respective companies. The photosensitive resin composition may contain two or more kinds of these.

15           [0097]

          The amount of the heat-crosslinker used in the present invention is preferably 0.5 parts by mass or more, more preferably 1 part by mass or more, still more preferably 3 parts by mass or more, with respect to 100 parts by mass of the component (A). With a view to maintaining the mechanical properties such as  
20           elongation, the amount is preferably 300 parts by mass or less, more preferably 200 parts by mass or less, still more preferably 100 parts by mass or less, still more preferably 70 parts by mass or less, particularly preferably 40 parts by mass or less.

[0098]

          The photosensitive resin composition of the present invention may optionally  
25           contain surfactants; esters such as ethyllactate and propyleneglycolmonomethyletheracetate; alcohols such as ethanol; ketones such as cyclohexanone and methylisobutylketone; and ethers such as tetrahydrofuran and

dioxane, for the purpose of enhancing wettability with a substrate.

[0099]

The preferable amount of a compound such as these used for the purpose of enhancing the wettability with a substrate is 0.001 parts by mass or more with respect to 100 parts by mass of the component (A), and is preferably 1800 parts by mass or less, more preferably 1500 parts by mass or less, with a view to obtaining a suitable film thickness.

[0100]

The photosensitive resin composition according to the present invention may contain inorganic particles. Preferable specific examples include, but are not limited to, silicon oxide, titanium oxide, barium titanate, alumina, talc, and the like.

[0101]

These inorganic particles preferably have an average primary particle diameter of 1 nm to 100 nm, more preferably 10 nm to 60 nm, in the light of photosensitivity. The individual particle diameters of these inorganic particles can be measured for length using a scanning electron microscope, for example, JSM-6301NF, a scanning electron microscope manufactured by JEOL Ltd. In this regard, the average primary particle diameter can be calculated by determining the arithmetic average of the diameters of 100 particles selected randomly from a photograph and measured for length.

[0102]

In order to enhance adhesion to a silicon substrate, the photosensitive resin composition may contain a silane coupling agent such as trimethoxyaminopropylsilane, trimethoxyepoxysilane, trimethoxyvinylsilane, or trimethoxythiolpropylsilane, to the extent that the storage stability is not impaired.

[0103]

The preferable amount of a compound such as these that is used to enhance the

adhesion with a silicon substrate is 0.01 parts by mass or more with respect to 100 parts by mass of the component (A), and is preferably 5 parts by mass or less, with a view to maintaining mechanical properties such as elongation.

[0104]

5           The photosensitive resin composition according to the present invention preferably has a viscosity of 2 to 5000 mPa·s. Adjusting the solid content such that the viscosity is 2 mPa·s or more makes it easier to obtain a desired film thickness. In addition, the viscosity of 5000 mPa·s or less makes it easier to obtain a highly uniform coating film. A resin composition having such a viscosity can be easily  
10           obtained, for example, by allowing the solid content to be 5 to 60 mass%.

[0105]

Next, a method of forming a resin pattern using the photosensitive resin composition according to the present invention will be described.

In a case where the photosensitive resin composition according to the present  
15           invention is directly applied to a substrate, examples of substrates to be used include, but are not limited to, wafers made of silicon, ceramics, gallium arsenide, or the like and substrates having metal formed as electrodes and wiring on the wafer. Examples of coating methods include methods such as spin coating using a spinner, spray coating, and roll coating. Although the thickness of a coating film varies  
20           depending on the coating technique, the viscosity and solid content of the composition, and the like, the composition is usually applied so that the film thickness obtained after drying becomes 0.1 to 150  $\mu\text{m}$ . In order to enhance the adhesion between a substrate such as a silicon wafer and the photosensitive resin composition, the substrate can also be pretreated with the above-mentioned silane  
25           coupling agent. For example, the surface is treated with a solution of 0.5 to 20 mass% by mass silane coupling agent dissolved in a solvent such as isopropanol, ethanol, methanol, water, tetrahydrofuran, propyleneglycolmonomethyletheracetate,

propyleneglycolmonomethylether, ethyllactate, or diethyl adipate, in which the surface is treated by spin coating, immersing, spray coating, or vapor treatment. Depending on the case, heat treatment at 50 to 300°C is then carried out to advance the reaction between the substrate and the silane coupling agent.

5 [0106]

Next, the substrate coated with the photosensitive resin composition is dried to afford a photosensitive resin composition coating. It is preferable to carry out the drying in a range of from 50 to 150°C for one minute to several hours using an oven, a hot plate, infrared light, or the like.

10 [0107]

Alternatively, in a case where the photosensitive resin composition according to the present invention is formed into a photosensitive resin sheet, it is preferable to form the photosensitive resin sheet by applying the composition onto a support film and drying it. A support film used for this is not limited to a particular one, but  
15 various films that are usually commercially available such as polyethylene terephthalate (PET) films, polyphenylene sulfide films, and polyimide films can be used. A surface treatment such as with silicone, a silane coupling agent, an aluminum chelating agent, or polyurea may be provided to the joining faces of the support film and the photosensitive resin sheet in order to enhance the adhesion and  
20 releasability of the joining faces. In addition, the thickness of the support film is not limited to a particular value, but is preferably in a range of from 10 to 100  $\mu\text{m}$  in the light of workability. The photosensitive resin composition applied on the support film undergoes a drying step. The drying temperature is preferably 50°C or more in the light of drying characteristics, and preferably 150°C or less in the light of  
25 prevention of loss of photosensitivity. In this regard, the photosensitive resin sheet has a film thickness of preferably 5  $\mu\text{m}$  or more in the light of level difference filling properties in laminate formation and preferably 150  $\mu\text{m}$  or less in the light of film

thickness uniformity.

[0108]

In addition, the photosensitive resin sheet according to the present invention may have a protection film on the sheet in order to protect the surface. This enables  
5 the photosensitive adhesive film surface to be protected from pollutants such as dirt and dust in the atmosphere.

[0109]

Examples of protection films include polyolefin films, polyester films, and the like. The protection film preferably has a smaller adhesive force to the  
10 photosensitive resin sheet.

[0110]

The obtained photosensitive resin sheet is attached to a substrate. Examples of substrates to be used include, but are not limited to, wafers made of silicon, ceramics, gallium arsenide, or the like and substrates having metal formed as electrodes and  
15 wiring on the wafer. In a case where the photosensitive resin sheet has a protection film, the latter is released, and the photosensitive resin sheet and a substrate are opposed to each other and attached together by thermo compression bonding, to thereby obtain a photosensitive adhesive composition coating. Thermo  
compression bonding can be carried out by thermal pressing, thermal laminating,  
20 thermal vacuum laminating, and the like. The attaching temperature is preferably 40°C or more in the light of adhesion and filling properties to a substrate. In addition, the attaching temperature is preferably 150°C or less in order to prevent the photosensitive adhesive film from being cured during attaching and thereby  
deteriorating the resolution of pattern formation in the processes of light exposure  
25 and development.

[0111]

Next, the photosensitive resin composition coating formed on the substrate by

the above-mentioned approach is irradiated with actinic rays through a mask having a desired pattern and is exposed to light. Examples of actinic rays used for light exposure include ultraviolet rays, visible rays, electron beams, X rays, and the like, and in the present invention, the i-line (365 nm), h-line (405 nm), and g-line (436 nm) of a mercury lamp are preferably used.

[0112]

In forming a pattern of a heat resistant resin, exposed parts are removed using a developing solution after exposure. A developing solution is preferably an aqueous solution of a compound having alkalinity, such as tetramethylammonium hydroxide, diethanolamine, diethylaminoethanol, sodium hydroxide, potassium hydroxide, sodium carbonate, potassium carbonate, triethylamine, diethylamine, methylamine, dimethylamine, dimethylaminoethylacetate, dimethylaminoethanol, dimethylaminoethylmethacrylate, cyclohexylamine, ethylenediamine and hexamethylenediamine. In some cases, to an alkali aqueous solution such as these, one of or a combination of two or more of the following may be added: polar solvents such as *N*-methyl-2-pyrrolidone, *N,N*-dimethylformamide, *N,N*-dimethylacetamide, dimethylsulfoxide,  $\gamma$ -butyrolactone, and dimethylacrylamide; alcohols such as methanol, ethanol, and isopropanol; esters such as ethyl lactate and propyleneglycolmonomethyletheracetate; and ketones such as cyclopentanone, cyclohexanone, isobutylketone, methylisobutylketone; and the like. After the development, rinsing treatment is preferably performed using water. Here, the rinse treatment may be carried out with water to which alcohols such as ethanol and isopropyl alcohol, esters such as ethyl lactate and propyleneglycolmonomethyletheracetate, or the like are added.

[0113]

After the development, a temperature of 150 to 500°C is applied to promote heat-crosslinking reaction, imide ring-closing reaction, and oxazole ring-closing

reaction, thereby enhancing the heat resistance and chemical resistance. This heat treatment is carried out for five minutes to five hours while raising temperature from one selected temperature to another in a stepwise manner or while raising temperature continuously in a selected temperature range. By way of an example, heat treatment is carried out at 130°C and 200°C, each for 30 minutes.

Alternatively, another example is a method such that temperature is raised linearly from room temperature to 400°C in two hours.

[0114]

A heat resistant resin coating formed from the photosensitive resin composition according to the present invention is suitably used in applications such as passivation films for semiconductors, protection films for semiconductor elements, interlayer insulating films for multilayer wiring for high-density mounting, and insulating layers of organic electroluminescent devices.

#### EXAMPLES

[0115]

The present invention will be described below by way of Examples, but the present invention is not limited by these Examples. First, evaluation procedures in Examples and Comparative Examples will be described. In evaluation of a photosensitive resin composition (hereinafter referred to as varnish), a varnish filtered through a 1 µm thick filter made of polytetrafluoroethylene (manufactured by Sumitomo Electric Industries, Ltd.) in advance was used.

[0116]

#### (1) Measurement of Content of Compound (C) in Photosensitive Resin Composition (Varnish)

A 0.03 g amount of the component (A) polymerized under using the compound (C) and 0.01 g of methyl 3-nitrobenzoate as an internal standard substance were dissolved in 0.7 g of deuterated dimethylsulfoxide, and the resultant mixture was

analyzed using an NMR instrument (GX-270, manufactured by JEOL Ltd.). The amount of the compound (C) contained in the component (A) was quantitated from each peak area on the basis of the area of a peak at about 3.9 ppm derived from 3-nitrobenzoate methyl.

5 [0117]

(2) Calculation of Total Amount of Compound (C) in Cured Film

Using a coater/developer, Mark-7 (manufactured by Tokyo Electron Limited), a varnish was applied to an 8-inch silicon wafer by spin coating, and baked on a hot plate at 120°C for 3 minutes to produce a prebaked film having a film thickness of  
10 3.2  $\mu\text{m}$ . Then, using the Mark-7 developer, the prebaked film was developed with 2.38 parts by mass of tetramethylammonium aqueous solution (hereinafter referred to as 2.38% TMAH, manufactured by Tama Chemicals Co., Ltd.), then rinsed with distilled water, and then shaken for drying, and the developed solid film was cured at 200°C under a nitrogen atmosphere for 60 minutes to obtain a cured film.

15 [0118]

The obtained cured film was measured for film thickness, and a 1  $\times$  5 cm piece was cut out of the cured film and subjected to adsorption trapping by a purge and trap method. Specifically, a sampled cured film was heated at 400°C for 60 minutes using helium as a purge gas, and the separated components were trapped  
20 into an adsorption tube.

[0119]

Using a thermal desorption unit, the trapped components were thermally desorbed under the primary desorption conditions, i.e., at 260°C for 15 minutes, and the secondary adsorption desorption conditions, i.e., at -27°C and 320°C for 5  
25 minutes, and then subjected to GC-MS analysis using a GC-MS device, 7890/5975C (manufactured by Agilent Technologies Japan, Ltd.), under the conditions including a column temperature of 40 to 300°C, a helium carrier gas (1.5 mL/min), and a

scanning range of  $m/Z$  from 29 to 600. The amount of gas generated was analyzed and calculated by using a calibration curve for each component of the compound (C) made by GC-MS under the same conditions as above-mentioned.

[0120]

5        The obtained value ( $\mu\text{g}$ ) was divided by an area of  $5\text{ cm}^2$  to afford a value in  $\mu\text{g}/\text{cm}^2$ . The value was divided by a value obtained by multiplying the specific gravity of the alkali-soluble resin (a) by the film thickness, and centuplicated to calculate the total compound (C) content in the cured film.

[0121]

#### 10        (3) Method of Measuring Film Thickness

After the prebaking, the thicknesses of the prebaked films were measured on the basis of polyimide using the Lambda Ace STM-602 manufactured by Dainippon Screen Manufacturing Co. Ltd. under the assumption that the refractive index was 1.629, and the thicknesses of the cured films were measured under the assumption  
15        that the refractive index was 1.773.

[0122]

#### (4) Adhesion Test

The adhesion to metal materials were tested by the following method.

[0123]

#### 20        <Making of Cured Film>

Copper was sputtered onto each silicon wafer to prepare a substrate having a metal material layer 200 nm thick formed on the surface (copper-sputtered substrate). A varnish was applied onto this substrate by a spin coating method using a spinner (manufactured by Mikasa Co., Ltd.), and then baked in a hot plate (D-SPIN,  
25        manufactured by Dai Nippon Screen Manufacturing Co., Ltd) at  $120^\circ\text{C}$  for 3 minutes to make a prebaked film which was finally  $8\text{ }\mu\text{m}$  thick. For a negative type photosensitive resin composition, the whole surface of the substrate is then exposed

to light at an exposure energy of 1000 mJ/cm<sup>2</sup> using an exposure machine, i.e., the i-line stepper NSR-2005i9C (manufactured by Nikon Corporation). These films were cured under a nitrogen gas flow (oxygen concentration: 20 ppm or less) using a clean oven (CLH-21CD-S, manufactured by Koyo Thermo Systems Co., Ltd.) at 140°C for 30 minutes and then at a raised temperature of 200°C for further one hour to afford a cured photosensitive resin film.

[0124]

#### <Adhesion Characteristics Evaluation>

The substrate was divided into two portions, and a single edged knife was used to make incisions in the form of a grid of 10 columns and 10 rows in the cured film on each substrate, each column and each row being 2 mm wide. One of the sample substrates was used to count how many out of the 100 cells were removed by peeling-off using cellophane tape, and was evaluated for the adhesion characteristics between the metal material and the cured resin film. On the other hand, a pressure cooker test (PCT) device (HAST CHAMBER EHS-211MD manufactured by Tabai Espec Corporation) was used to treat the other sample substrate for PCT under the saturation conditions at 121°C at 2 atmospheres for 400 hours, and then the peeling-off test as above-mentioned was carried out. For each substrate, the substrate was rated A if the number of pieces peeled thereoff in the peeling-off test was less than 10, and rated B if it was 10 or more and less than 20, and rated C if it was 20 or more.

[0125]

#### (5) Coatability Evaluation

A varnish was spin coated on a substrate having level differences, and then baked using a hot plate (the coater/developer, Act-8, manufactured by Tokyo Electron Limited) at 120°C for 3 minutes to produce a prebaked film having an average thickness of 10 μm. The prebaked film was irradiated using a sodium lamp, and the surface was visually observed. The surfaces having no streak were rated ○,

and those having a streak(s) generated thereon were rated ×. Then, the thicknesses of the film that covered the level differences and filling portions on the substrate in the prebaked film were measured by observing the cross section of the level differences on the substrate using a field emission type scanning electron microscope (S-4800, manufactured by Hitachi High-Technologies Corporation). The peripheral portion 10 mm crosswise from each side was removed from the substrate, and the remaining portion was divided into 30 parts to afford 30 measurement points. The level difference filling properties were calculated using the following equations:

Largest Height = Average Value of Total of Heights of Level Differences on Substrate and Film Thicknesses in Prebake Film that Cover Level Differences

Film Thickness of Filling Portions = Average Value of Film Thicknesses of Centers of Filling Portions

Level Difference Filling Properties (%) = [Largest Height / Film Thickness of Filling Portions] × 100

Here, the level difference filling properties are preferably 90 to 100%, more preferably 95 to 100%. Level difference filling properties of 95% or more and 100% or less were rated A, 90 or more and less than 95% were rated B, and less than 90% were rated C.

[0126]

The substrates having level differences used for evaluation were made by the following method. On an 8-inch silicon wafer, a photoresist film of OFPR (which is a tradename and manufactured by Tokyo Ohka Kogyo Co., Ltd.) was formed, a pattern was formed by photolithography, dryetching was carried out with this pattern as a mask using an etching device (RIE-10N, manufactured by Samco Inc.), and the pattern composed of OFPR was released with acetone to form level differences having a depth of 4 μm.

[0127]

## [Synthesis Example 1] Synthesis of Diamine Compound (HA)

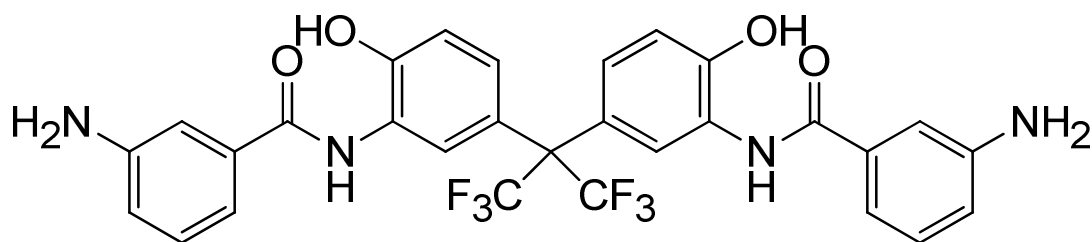
A 164.8 g (0.45 mol) amount of 2,2-bis(3-amino-4-hydroxyphenyl)hexafluoropropane (hereinafter referred to as BAHF) was dissolved in 900 mL of acetone and 156.8 g (2.7 mol) of propyleneoxide, and the resulting solution was cooled to -15°C. To the resulting solution, a solution of 183.7 g (0.99 mole) of 3-nitrobenzoyl chloride dissolved in 900 mL of acetone was added dropwise. After completion of the dropwise addition, the solution was allowed to react at -15°C for four hours and then warmed to room temperature. A precipitated white solid material was filtered off and then dried in vacuo at 50°C.

[0128]

A 270 g amount of the solid material was introduced into a 3-L stainless steel autoclave and was then dispersed in 2400 mL of methylcellosolve, and then 5 g of 5% palladium-carbon was added thereto. Hydrogen was introduced into the reaction solution using a balloon to perform a reduction reaction at room temperature. After two hours, it was confirmed that the balloon could not shrink any more, and the reaction was terminated. After completion of the reaction, the reaction solution was filtered to remove the palladium compound that was a catalyst, and then the filtrate was concentrated with a rotary evaporator to produce a diamine compound (hereinafter referred to as HA) represented by the following formula.

[0129]

[Chem. 19]



[0130]

## [Synthesis Example 2] Synthesis of Polyimide Resin (A-1)

Under a dry nitrogen gas flow, 62.04 g (0.2 mol) of bis(3,4-dicarboxyphenyl) ether dianhydride (hereinafter referred to as ODP A) was dissolved in 1,000 g of *N*-methyl-2-pyrrolidone (hereinafter referred to as NMP). To the resulting solution, 58.60 g (0.16 mol) of BAHF, 12.00 g (0.02 mol) of ED-600 (which is a tradename and manufactured by HUNTSMAN Corporation), and 4.37 g (0.04 mol) of 3-aminophenol as an end-capping agent were added together with 250 g of NMP, and the resulting mixture was allowed to react at 60°C for one hour and further react at 160°C for six hours. After completion of the reaction, the solution was cooled to room temperature, and the solution was poured into 10 L of water to obtain a white precipitate. This precipitate was collected by filtration, washed with water three times, and dried in a vacuum oven at 80°C for 40 hours to obtain a polyimide resin (A-1).

[0131]

#### [Synthesis Example 3] Synthesis of Polyimide Resin (A-2)

A polyimide resin (A-2) was obtained by synthesis in the same manner as in Synthesis Example 2 except that the polymer solvent in Synthesis Example 2 was changed from NMP to 1,3-dimethyl-2-imidazolidinone (hereinafter referred to as DMI). The NMR analysis results revealed that the DMI content was 3.0 parts by mass with respect to 100 parts by mass of the polyimide resin (A-2).

[0132]

#### [Synthesis Example 4] Synthesis of Polyimide Resin (A-3)

A polyimide resin (A-3) was obtained by synthesis in the same manner as in Synthesis Example 2 except that the polymer solvent in Synthesis Example 2 was changed from NMP to 3-methoxy-*N,N*-dimethylpropionamide (hereinafter referred to as EQUAMIDE M100). The NMR analysis results revealed that the EQUAMIDE M100 content was 2.8 parts by mass with respect to 100 parts by mass of the polyimide resin (A-3).

[0133]

[Synthesis Example 5] Synthesis of Polyimide Resin (A-4)

A polyimide resin (A-4) was obtained by synthesis in the same manner as in Synthesis Example 2 except that the polymer solvent in Synthesis Example 2 was  
5 changed from NMP to *N,N*-dimethylpropyleneurea (hereinafter referred to as DMPU). The NMR analysis results revealed that the DMPU content was 3.1 parts by mass with respect to 100 parts by mass of the polyimide resin (A-4).

[0134]

[Synthesis Example 6] Synthesis of Polyimide Resin (A-5)

10 A polyimide resin (A-5) was obtained by synthesis in the same manner as in Synthesis Example 2 except that the polymer solvent in Synthesis Example 2 was changed from NMP to 3-butoxy-*N,N*-dimethylpropionamide (hereinafter referred to as EQUAMIDE B100). The NMR analysis results revealed that the EQUAMIDE B100 content was 3.2 parts by mass with respect to 100 parts by mass of the  
15 polyimide resin (A-5).

[0135]

[Synthesis Example 7] Synthesis of Polyimide Precursor Resin (A-6)

Under a dry nitrogen gas flow, 62.04 g (0.2 mol) of ODPA was dissolved in 1000 g of NMP. To this, 96.72 g (0.16 mol) of HA and 4.97 g (0.02 mol) of 1,3-  
20 bis(3-aminopropyl)tetramethyldisiloxane, together with 100 g of NMP, were added, and the resulting mixture was allowed to react at 20°C for one hour and then react at 50°C for two hours. Then, 4.37 g (0.04 mol) of 3-aminophenol as an end-capping agent, together with 30 g of NMP, was added and allowed to react at 50°C for two hours. Subsequently, to the resulting solution, a solution prepared by diluting 47.66  
25 g (0.4 mol) of *N,N*-dimethylformamide dimethylacetal with 50 g of NMP was added dropwise over 10 minutes. After the dropwise addition, the solution was stirred at 50°C for three hours. After completion of the stirring, the solution was cooled to

room temperature, and the solution was poured into 1 L of water to obtain a precipitate. This precipitate was collected by filtration, washed with water three times, and dried in a vacuum oven at 80°C for 20 hours to obtain a powder of polyimide precursor resin (A-6).

5 [0136]

[Synthesis Example 8] Synthesis of Polyamide Resin (A-7)

Under a dry nitrogen gas flow, 88.64 g (0.18 mol) of dicarboxylic diester made of 4,4'-dicarboxydiphenylether and 1-hydroxybenzotriazole, 65.93 g (0.18 mol) of BAHF, 12.00 g (0.02 mol) of ED-600 (which is a tradename and manufactured by HUNTSMAN Corporation), and 800 g of NMP were allowed to react at 25°C for 30 minutes, then heated in an oil bath, and allowed to react at 80°C for eight hours. Next, 12.31 g (0.075 mol) of 5-norbornene-2,3-dicarboxylic anhydride as an end-capping agent was added, the resulting solution was stirred at 80°C for another three hours, and the reaction was terminated. After completion of the reaction, the solution was cooled to room temperature, then the reaction mixture was filtered, and the reaction mixture was poured into 2 L of a liquid mixture of water/isopropanol at 3/1 (volume ratio) to obtain a precipitate. This precipitate was collected by filtration, washed with water three times, and dried in a vacuum oven at 80°C for 20 hours to obtain a polyamide resin (A-7) (polybenzoxazole precursor).

15 20 [0137]

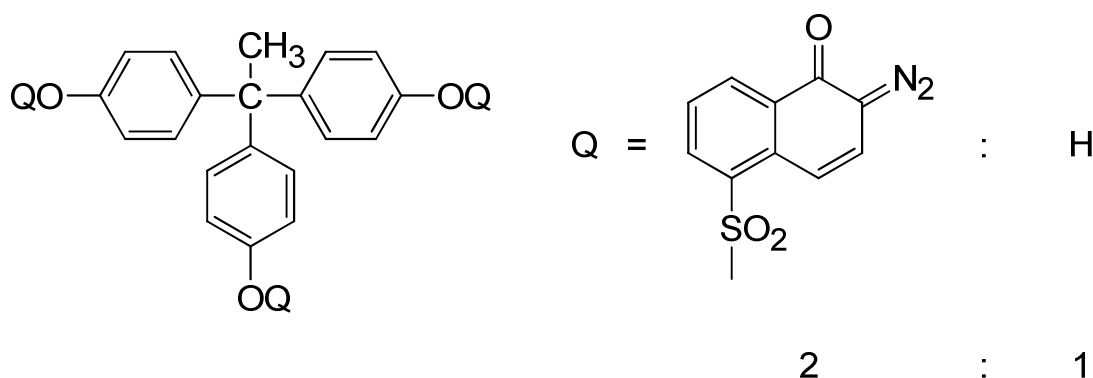
[Synthesis Example 9] Synthesis of Quinonediazide Compound (b-2-1)

Under a dry nitrogen gas flow, 20 g of TrisP-HAP (which is a tradename and manufactured by Honshu Chemical Industry Co., Ltd.) and 35.08 g (0.131 mol) of 5-naphthoquinonediazidesulfonyl chloride (NAC-5, manufactured by Toyo Gosei Co., Ltd.) were dissolved in 1000 g of 1,4-dioxane. To this, a liquid mixture of 150 g of 1,4-dioxane and 14.53 g (0.14 mol) of triethylamine was added dropwise in the reaction container on ice in such a manner that the temperature in the system was not

35°C or higher. After the dropwise addition, the solution was stirred at 30°C for two hours. The triethylamine salt was filtered, and the filtrate was introduced into 7 L of pure water to obtain a precipitate. This precipitate was collected by filtration and then washed with 2 L of 1 mass% hydrochloric acid. Subsequently, the washed product was further washed with 5 L of pure water two times. This precipitate was dried in a vacuum oven at 50°C for 24 hours to obtain a quinonediazide compound (b-2-1) represented by the following formula in which two of the Qs on the average were 5-naphthoquinonediazidesulfonic-acid-esterified.

[0138]

[Chem. 20]



[0139]

The names and structures of the compounds shown in Tables 1 to 3 are as follows:

b-1-1: 1,9-nonanediol dimethacrylate

b-1-2: 1,2-octanedione-1-[4-(phenylthio)phenyl]-2-(o-benzoyloxime) (OXE02)

C-1: delta-valerolactone (boiling point: 230°C)

C-2: diethyleneglycolbutyl ether (boiling point: 230°C)

C-3: 2-phenoxyethanol (boiling point: 245°C)

C-4: 1,3-dimethyl-2-imidazolidinone (boiling point: 220°C)

C-5: 3-methoxy-*N,N*-dimethylpropionamide (boiling point: 216°C)

C-6: *N,N*-dimethylpropylene urea (boiling point: 246°C)

C-7: 3-butoxy-*N,N*-dimethylpropionamide (boiling point: 252°C)

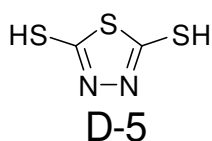
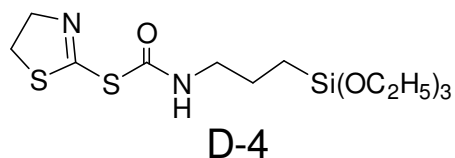
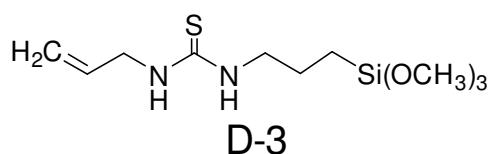
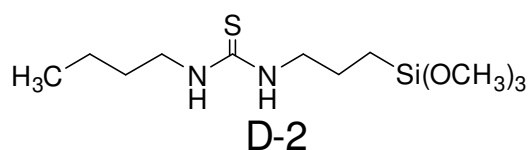
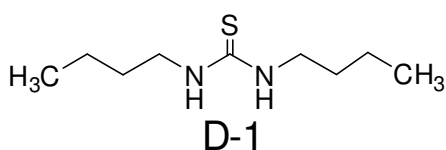
C-8: *N*-cyclohexyl-2-pyrrolidone (boiling point: 154°C/7 mmHg, 305°C in terms of the boiling point at normal pressure)

C-9: *N,N*-dimethylformamide (boiling point: 153°C)

5 D-1 to D-5: the following equations:

[0140]

[Chem. 21]

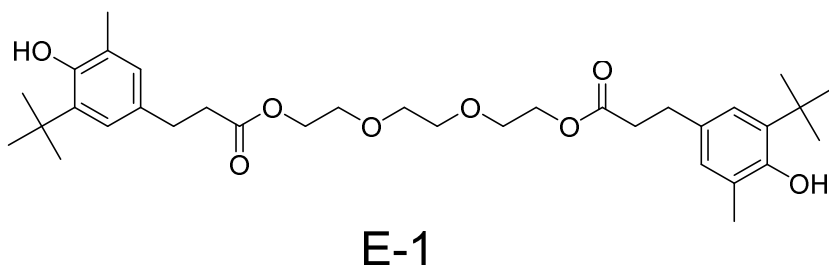


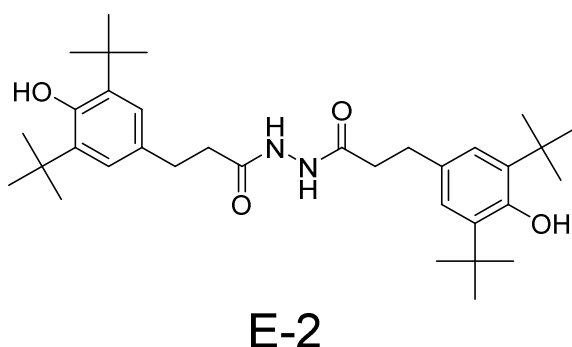
[0141]

10 E-1, E-2: the following equations:

[0142]

[Chem. 22]





[0143]

F-1: HMOM-TPHAP (which is a tradename and manufactured by Honshu Chemical Industry Co., Ltd.) as a heat-crosslinker, which is an alkoxymethyl compound having an acidic group

[Examples 1 to 53, Comparative Examples 1 to 6]

Below, Example 1 will be specifically described as an example. To 10 g of the obtained resin (A-2), 1.5 g of (b-1-1) as the (B) photosensitizer, 3.0 g of (b-1-2), and 0.30 g of (C-1) as the compound (C) were added, and to the resulting mixture, 20 g of  $\gamma$ -butyrolactone (GBL) as a solvent was added to produce a varnish. Similarly, in Examples 2 to 53 and Comparative Examples 1 to 6, varnishes were produced in accordance with the formulations in Tables 1 to 3. The characteristics of the produced varnishes were measured using the above-mentioned evaluation methods. The obtained results are shown in Tables 4 to 6. In this regard, Examples 1 to 53 and Comparative Examples 1 to 6 were all carried out using 20 g of GBL as a solvent.





[0145]

[Table 2]

|            | Varnish | Resin A |     | Photosensitizer (B) |      | Compound (C) |       | Compound (D) |       | Compound (E) |  | Crosslinker | Remarks                            |
|------------|---------|---------|-----|---------------------|------|--------------|-------|--------------|-------|--------------|--|-------------|------------------------------------|
| Example 21 | W-21    | A-1     | 10g | b-2-1               | 3.5g | C-3          | 0.30g |              |       |              |  |             |                                    |
| Example 22 | W-22    | A-1     | 10g | b-2-1               | 3.5g | C-4          | 0.30g |              |       |              |  |             |                                    |
| Example 23 | W-23    | A-1     | 10g | b-2-1               | 3.5g | C-5          | 0.30g |              |       |              |  |             |                                    |
| Example 24 | W-24    | A-1     | 10g | b-2-1               | 3.5g | C-6          | 0.30g |              |       |              |  |             |                                    |
| Example 25 | W-25    | A-1     | 10g | b-2-1               | 3.5g | C-7          | 0.30g |              |       |              |  |             |                                    |
| Example 26 | W-26    | A-1     | 10g | b-2-1               | 3.5g | C-8          | 0.30g |              |       |              |  |             |                                    |
| Example 27 | W-27    | A-1     | 10g | b-2-1               | 3.5g | C-4          | 0.30g |              |       |              |  | F-1         | 4.5g                               |
| Example 28 | W-28    | A-1     | 10g | b-2-1               | 3.5g | C-5          | 0.30g |              |       |              |  | F-1         | 4.5g                               |
| Example 29 | W-29    | A-1     | 10g | b-2-1               | 3.5g | C-6          | 0.30g |              |       |              |  | F-1         | 4.5g                               |
| Example 30 | W-30    | A-1     | 10g | b-2-1               | 3.5g | C-7          | 0.30g |              |       |              |  | F-1         | 4.5g                               |
| Example 31 | W-31    | A-1     | 10g | b-2-1               | 3.5g | C-8          | 0.30g |              |       |              |  | F-1         | 4.5g                               |
| Example 32 | W-32    | A-2     | 10g | b-1-1               | 1.5g | C-4          | 0.30g |              |       |              |  |             | containing Compound (C) in advance |
|            |         |         |     | b-1-2               | 3.0g |              |       |              |       |              |  |             |                                    |
| Example 33 | W-33    | A-3     | 10g | b-1-1               | 1.5g | C-5          | 0.28g |              |       |              |  |             | containing Compound (C) in advance |
|            |         |         |     | b-1-2               | 3.0g |              |       |              |       |              |  |             |                                    |
| Example 34 | W-34    | A-4     | 10g | b-1-1               | 1.5g | C-6          | 0.31g |              |       |              |  |             | containing Compound (C) in advance |
|            |         |         |     | b-1-2               | 3.0g |              |       |              |       |              |  |             |                                    |
| Example 35 | W-35    | A-5     | 10g | b-1-1               | 1.5g | C-7          | 0.32g |              |       |              |  |             | containing Compound (C) in advance |
|            |         |         |     | b-1-2               | 3.0g |              |       |              |       |              |  |             |                                    |
| Example 36 | W-36    | A-2     | 10g | b-2-1               | 3.5g | C-4          | 0.30g |              |       |              |  |             | containing Compound (C) in advance |
| Example 37 | W-37    | A-3     | 10g | b-2-1               | 3.5g | C-5          | 0.28g |              |       |              |  |             | containing Compound (C) in advance |
| Example 38 | W-38    | A-4     | 10g | b-2-1               | 3.5g | C-6          | 0.31g |              |       |              |  |             | containing Compound (C) in advance |
| Example 39 | W-39    | A-5     | 10g | b-2-1               | 3.5g | C-7          | 0.32g |              |       |              |  |             | containing Compound (C) in advance |
|            |         |         |     | b-1-1               | 1.5g |              |       |              |       |              |  |             |                                    |
| Example 40 | W-40    | A-2     | 10g | b-1-2               | 3.0g | C-4          | 0.30g | D-1          | 0.15g |              |  |             | containing Compound (C) in advance |

[0146]

[Table 3]

|                       | Varnish | Resin A | Photosensitizer (B) |              | Compound (C) |       | Compound (D) |       | Compound (E) |       | Crosslinker | Remarks                            |
|-----------------------|---------|---------|---------------------|--------------|--------------|-------|--------------|-------|--------------|-------|-------------|------------------------------------|
|                       |         |         | b-1-1               | b-1-2        | C-4          | 0.30g | D-2          | 0.15g |              |       |             |                                    |
| Example 41            | W-41    | A-2     | 10g                 | 1.5g<br>3.0g | C-4          | 0.30g | D-2          | 0.15g |              |       |             | containing Compound (C) in advance |
| Example 42            | W-42    | A-2     | 10g                 | 1.5g<br>3.0g | C-4          | 0.30g | D-3          | 0.15g |              |       |             | containing Compound (C) in advance |
| Example 43            | W-43    | A-2     | 10g                 | 1.5g<br>3.0g | C-4          | 0.30g | D-4          | 0.15g |              |       |             | containing Compound (C) in advance |
| Example 44            | W-44    | A-2     | 10g                 | 1.5g<br>3.0g | C-4          | 0.30g | D-5          | 0.15g |              |       |             | containing Compound (C) in advance |
| Example 45            | W-45    | A-2     | 10g                 | 3.5g         | C-4          | 0.30g | D-1          | 0.15g |              |       |             | containing Compound (C) in advance |
| Example 46            | W-46    | A-2     | 10g                 | 3.5g         | C-4          | 0.30g | D-2          | 0.15g |              |       |             | containing Compound (C) in advance |
| Example 47            | W-47    | A-2     | 10g                 | 3.5g         | C-4          | 0.30g | D-3          | 0.15g |              |       |             | containing Compound (C) in advance |
| Example 48            | W-48    | A-2     | 10g                 | 3.5g         | C-4          | 0.30g | D-4          | 0.15g |              |       |             | containing Compound (C) in advance |
| Example 49            | W-49    | A-2     | 10g                 | 3.5g         | C-4          | 0.30g | D-5          | 0.15g |              |       |             | containing Compound (C) in advance |
| Example 50            | W-50    | A-2     | 10g                 | 1.5g<br>3.0g | C-4          | 0.30g | D-1          | 0.15g | E-1          | 0.15g |             | containing Compound (C) in advance |
| Example 51            | W-51    | A-2     | 10g                 | 1.5g<br>3.0g | C-4          | 0.30g | D-1          | 0.15g | E-2          | 0.15g |             | containing Compound (C) in advance |
| Example 52            | W-52    | A-2     | 10g                 | 3.5g         | C-4          | 0.30g | D-1          | 0.15g | E-1          | 0.15g |             | containing Compound (C) in advance |
| Example 53            | W-53    | A-2     | 10g                 | 3.5g         | C-4          | 0.30g | D-1          | 0.15g | E-2          | 0.15g |             | containing Compound (C) in advance |
| Comparative Example 1 | W-54    | A-1     | 10g                 | 1.5g<br>3.0g |              |       |              |       |              |       |             |                                    |
| Comparative Example 2 | W-55    | A-1     | 10g                 | 1.5g<br>3.0g | C-9          | 0.30g |              |       |              |       |             |                                    |
| Comparative Example 3 | W-56    | A-6     | 10g                 | 1.5g<br>3.0g |              |       |              |       |              |       |             |                                    |
| Comparative Example 4 | W-57    | A-7     | 10g                 | 1.5g<br>3.0g |              |       |              |       |              |       |             |                                    |
| Comparative Example 5 | W-58    | A-1     | 10g                 | 3.5g         |              |       |              |       |              |       |             |                                    |
| Comparative Example 6 | W-59    | A-1     | 10g                 | 1.5g<br>3.0g | C-4          | 3g    |              |       |              |       |             |                                    |

[0147]

[Table 4]

|            | Varnish | Adhesion (PCT) |           | Coatability |                                     | Compound (C) in Cured Film |
|------------|---------|----------------|-----------|-------------|-------------------------------------|----------------------------|
|            |         | 0 hours        | 400 hours | Streak      | Level Difference Filling Properties |                            |
| Example 1  | W-1     | A              | B         | ○           | A                                   | 0.20%                      |
| Example 2  | W-2     | A              | B         | ○           | A                                   | 0.21%                      |
| Example 3  | W-3     | A              | B         | ○           | A                                   | 0.31%                      |
| Example 4  | W-4     | A              | A         | ○           | A                                   | 0.18%                      |
| Example 5  | W-5     | A              | A         | ○           | A                                   | 0.13%                      |
| Example 6  | W-6     | A              | A         | ○           | A                                   | 0.37%                      |
| Example 7  | W-7     | A              | A         | ○           | A                                   | 0.41%                      |
| Example 8  | W-8     | A              | A         | ○           | A                                   | 1.4%                       |
| Example 9  | W-9     | A              | B         | ○           | A                                   | 0.16%                      |
| Example 10 | W-10    | A              | B         | ○           | A                                   | 0.11%                      |
| Example 11 | W-11    | A              | B         | ○           | A                                   | 0.26%                      |
| Example 12 | W-12    | A              | B         | ○           | A                                   | 0.31%                      |
| Example 13 | W-13    | A              | B         | ○           | A                                   | 1.3%                       |
| Example 14 | W-14    | B              | B         | ○           | A                                   | 0.14%                      |
| Example 15 | W-15    | B              | B         | ○           | A                                   | 0.10%                      |
| Example 16 | W-16    | B              | B         | ○           | A                                   | 0.21%                      |
| Example 17 | W-17    | B              | B         | ○           | A                                   | 0.27%                      |
| Example 18 | W-18    | B              | B         | ○           | A                                   | 1.1%                       |
| Example 19 | W-19    | B              | B         | ○           | A                                   | 0.24%                      |
| Example 20 | W-20    | B              | B         | ○           | A                                   | 0.24%                      |

[0148]

[Table 5]

|            | Varnish | Adhesion (PCT) |           | Coatability |                                     | Compound (C) in Cured Film |
|------------|---------|----------------|-----------|-------------|-------------------------------------|----------------------------|
|            |         | 0 hours        | 400 hours | Streak      | Level Difference Filling Properties |                            |
| Example 21 | W-21    | B              | B         | ○           | A                                   | 0.30%                      |
| Example 22 | W-22    | B              | B         | ○           | A                                   | 0.23%                      |
| Example 23 | W-23    | B              | B         | ○           | A                                   | 0.22%                      |
| Example 24 | W-24    | B              | B         | ○           | A                                   | 0.42%                      |
| Example 25 | W-25    | B              | B         | ○           | A                                   | 0.40%                      |
| Example 26 | W-26    | B              | B         | ○           | A                                   | 0.54%                      |
| Example 27 | W-27    | A              | B         | ○           | A                                   | 0.23%                      |
| Example 28 | W-28    | A              | B         | ○           | A                                   | 0.22%                      |
| Example 29 | W-29    | A              | B         | ○           | A                                   | 0.42%                      |
| Example 30 | W-30    | A              | B         | ○           | A                                   | 0.40%                      |
| Example 31 | W-31    | B              | B         | ○           | A                                   | 0.54%                      |
| Example 32 | W-32    | A              | A         | ○           | A                                   | 0.18%                      |
| Example 33 | W-33    | A              | A         | ○           | A                                   | 0.13%                      |
| Example 34 | W-34    | A              | A         | ○           | A                                   | 0.37%                      |
| Example 35 | W-35    | A              | A         | ○           | A                                   | 0.41%                      |
| Example 36 | W-36    | A              | A         | ○           | A                                   | 0.23%                      |
| Example 37 | W-37    | A              | A         | ○           | A                                   | 0.22%                      |
| Example 38 | W-38    | A              | A         | ○           | A                                   | 0.42%                      |
| Example 39 | W-39    | A              | A         | ○           | A                                   | 0.40%                      |
| Example 40 | W-40    | A              | A         | ○           | A                                   | 0.18%                      |

[0149]

[Table 6]

|                       | Varnish | Adhesion (PCT) |           | Coatability |                                     | Compound (C) in Cured Film |
|-----------------------|---------|----------------|-----------|-------------|-------------------------------------|----------------------------|
|                       |         | 0 hours        | 400 hours | Streak      | Level Difference Filling Properties |                            |
|                       |         |                |           |             |                                     |                            |
| Example 41            | W-41    | A              | A         | ○           | A                                   | 0.19%                      |
| Example 42            | W-42    | A              | A         | ○           | A                                   | 0.18%                      |
| Example 43            | W-43    | A              | A         | ○           | A                                   | 0.20%                      |
| Example 44            | W-44    | A              | A         | ○           | A                                   | 0.18%                      |
| Example 45            | W-45    | A              | A         | ○           | A                                   | 0.21%                      |
| Example 46            | W-46    | A              | A         | ○           | A                                   | 0.21%                      |
| Example 47            | W-47    | A              | A         | ○           | A                                   | 0.23%                      |
| Example 48            | W-48    | A              | A         | ○           | A                                   | 0.21%                      |
| Example 49            | W-49    | A              | A         | ○           | A                                   | 0.21%                      |
| Example 50            | W-50    | A              | A         | ○           | A                                   | 0.18%                      |
| Example 51            | W-51    | A              | A         | ○           | A                                   | 0.19%                      |
| Example 52            | W-52    | A              | A         | ○           | A                                   | 0.21%                      |
| Example 53            | W-53    | A              | A         | ○           | A                                   | 0.21%                      |
| Comparative Example 1 | W-54    | C              | C         | ×           | C                                   | none                       |
| Comparative Example 2 | W-55    | B              | C         | ×           | B                                   | none                       |
| Comparative Example 3 | W-56    | C              | C         | ×           | C                                   | none                       |
| Comparative Example 4 | W-57    | C              | C         | ×           | C                                   | none                       |
| Comparative Example 5 | W-58    | C              | C         | ×           | C                                   | none                       |
| Comparative Example 6 | W-59    | A              | C         | ×           | A                                   | 5.8%                       |

[0150]

The addition of the compound (C) enhanced coatability and adhesion. In contrast, C-9, which is *N,N*-dimethylformamide (boiling point: 153°C), did not enhance coatability nor adhesion.

## CLAIMS

1. A photosensitive resin composition comprising:

(A) an alkali soluble resin containing an organic group derived from an aliphatic diamine,

(B) a photosensitizer, and

(C) a compound that is liquid under conditions of 1013 hPa and 25°C and has a boiling point of 210°C or more,

wherein said photosensitive resin composition contains 0.1 to 15 parts by mass of said compound (C) that is liquid under conditions of 1013 hPa and 25°C and has a boiling point of 210°C or more with respect to 100 parts by mass of said alkali soluble resin (A) containing an organic group derived from an aliphatic diamine.

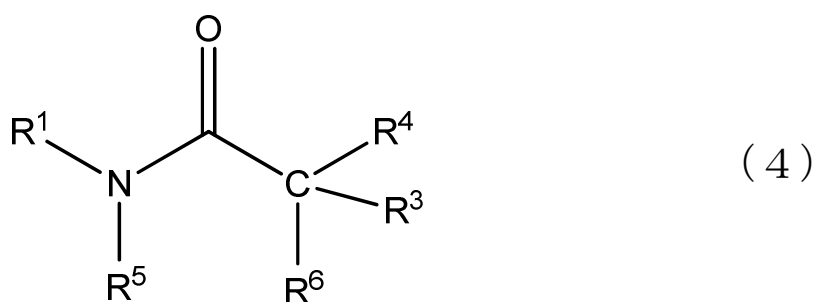
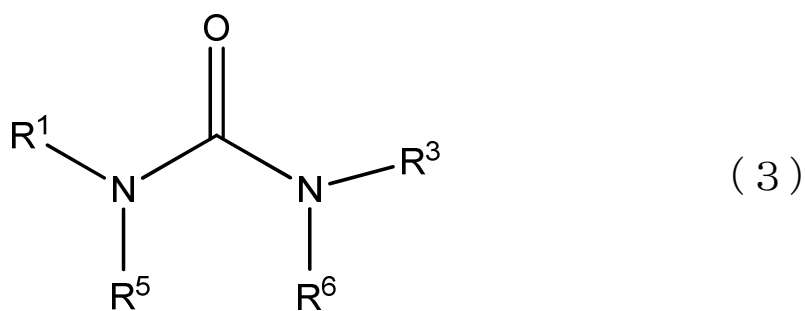
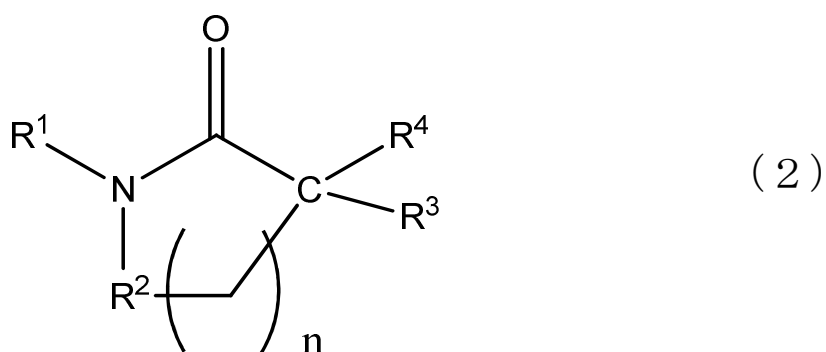
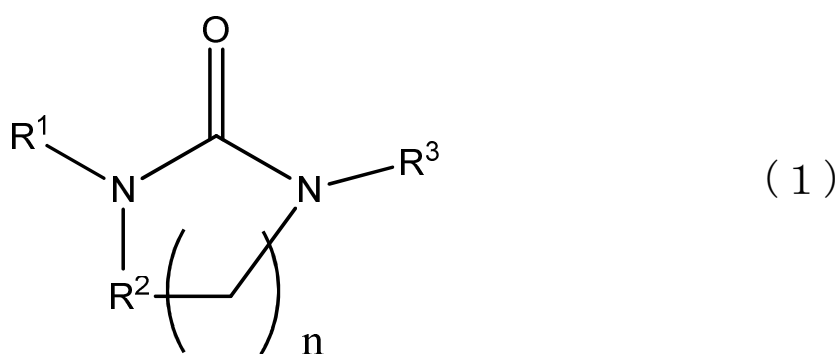
2. The photosensitive resin composition according to claim 1, wherein said alkali soluble resin (A) having an organic group derived from an aliphatic diamine comprises one or more resins selected from polyimides, polybenzoxazole, polyamideimides, and precursors thereof.

3. The photosensitive resin composition according to claim 1 or 2, wherein said photosensitizer (B) is a photoinitiator crosslinker.

4. The photosensitive resin composition according to claim 1 or 2, wherein said photosensitizer (B) is a photo-acid generator.

5. The photosensitive resin composition according to any one of claims 1 to 4, wherein said compound (C) that is liquid under conditions of 1013 hPa and 25°C and has a boiling point of 210°C or more is one or more compounds selected from the compounds represented by the general formulae (1) to (4):

[Chem. 1]



5 (wherein, in the general formulae (1) to (4), R<sup>1</sup> represents hydrogen or a C<sub>1</sub>-C<sub>5</sub> alkyl group;

R<sup>2</sup> represents a C<sub>1</sub>-C<sub>5</sub> bivalent organic group;

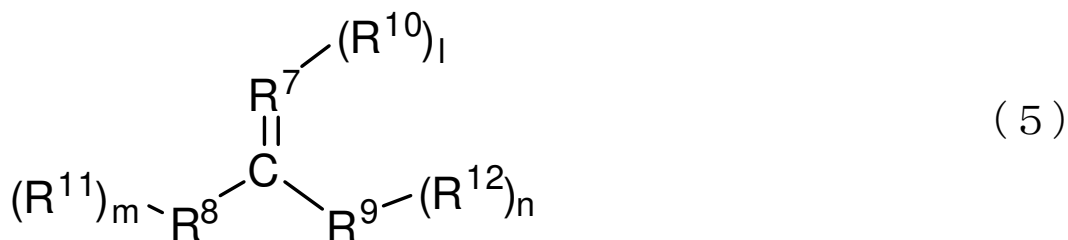
R<sup>5</sup> represents hydrogen or a C<sub>1</sub>-C<sub>5</sub> organic group;

R<sup>3</sup>, R<sup>4</sup>, and R<sup>6</sup> independently represent a C<sub>1</sub>-C<sub>5</sub> organic group; and

n represents an integer number of 1 to 3.)

6. The photosensitive resin composition according to any one of claims 1 to 5, further comprising (D) a compound represented by the general formula (5):

[Chem. 2]



(wherein, in the general formula (5), R<sup>7</sup> to R<sup>9</sup> represent any of an oxygen atom, sulfur atom, and nitrogen atom, and at least one of R<sup>7</sup> to R<sup>9</sup> represents a sulfur atom;

l represents 0 or 1;

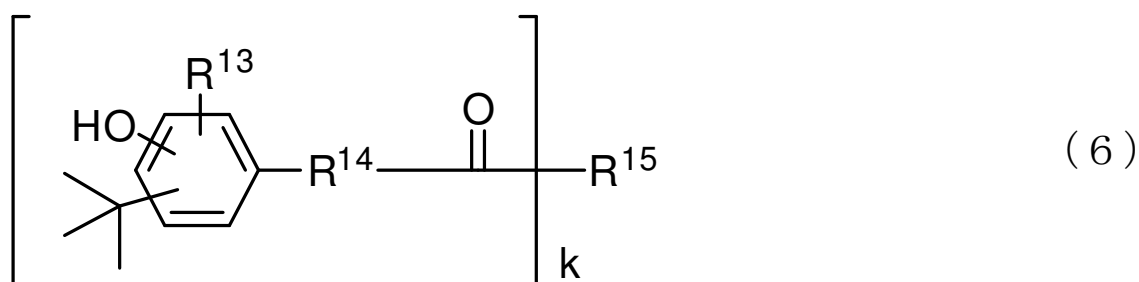
R<sup>7</sup> represents an oxygen atom or sulfur atom when l is 0 and represents a nitrogen atom when l is 1;

m and n represent 1 or 2; and

R<sup>10</sup> to R<sup>12</sup> independently represent a hydrogen atom or a C<sub>1</sub>-C<sub>20</sub> organic group.)

7. The photosensitive resin composition according to any one of claims 1 to 6, further comprising (E) a compound represented by the general formula (6):

[Chem. 3]



(wherein, in the general formula (6), R<sup>13</sup> represents a hydrogen atom or an alkyl group having one or more carbon atoms;

R<sup>14</sup> represents an alkylene group having two or more carbon atoms;

R<sup>15</sup> represents a monovalent to tetravalent organic group containing at least any

of an alkylene group having two or more carbon atoms, an oxygen atom, and a nitrogen atom; and

k represents an integer number of 1 to 4.)

8. A photosensitive resin sheet formed from said photosensitive resin composition according to any one of claims 1 to 7.

9. A cured film formed by curing said photosensitive resin composition according to any one of claims 1 to 7 or said photosensitive resin sheet according to claim 8.

10. The cured film according to claim 9, comprising 0.005 mass% to 5 mass% of said compound (C) that is liquid under conditions of 1013 hPa and 25°C and has a boiling point of 210°C or more.

11. A method of producing a relief pattern of a cured film, the method comprising the steps of:

applying said photosensitive resin composition according to any one of claims 1 to 7 to a substrate, or laminating said photosensitive resin sheet according to claim 8 on a substrate, and drying said photosensitive resin composition or said photosensitive resin sheet to form a photosensitive resin film;

exposing said photosensitive resin film through a mask;

developing said photosensitive resin film with an alkali solution after said exposing; and

heating said photosensitive resin film after said developing.

12. The method of producing a relief pattern of a cured film according to claim 11, wherein said step of applying said photosensitive resin composition to said substrate and drying said photosensitive resin composition to form a photosensitive resin film comprises a step of applying said photosensitive resin composition to said substrate using a slit nozzle.

13. An organic EL display device, comprising:

a drive circuit,

a planarizing layer on said drive circuit,  
a first electrode, and  
an insulating layer on said first electrode,

wherein said cured film according to claim 9 or 10 is disposed on at least one of  
5 said planarizing layer and said insulating layer.

14. A semiconductor electronic component or a semiconductor device, wherein said  
cured film according to claim 9 or 10 is disposed as an interlayer insulating film  
between rewirings.

15. The semiconductor electronic component or the semiconductor device  
10 according to claim 14, wherein said rewirings are copper metal wirings, and the  
width of each of said copper metal wirings and a spacing between said copper metal  
wirings adjacent to each other are each 5  $\mu\text{m}$  or less.

16. A semiconductor electronic component or a semiconductor device, wherein said  
cured film according to claim 9 or 10 is disposed as an interlayer insulating film  
15 between rewirings on a molding resin substrate on which a silicon chip is disposed.

17. A method of producing a semiconductor electronic component or a  
semiconductor device, the method comprising the steps of:

disposing said cured film according to claim 9 or 10 as an interlayer insulating  
film between rewirings on a support substrate on which a tentative attaching material  
20 is disposed;

disposing a silicon chip and a molding resin on said cured film; and  
then releasing said support substrate having said tentative attaching material  
disposed thereon and said rewirings.

18. A semiconductor electronic component or a semiconductor device, wherein said  
25 cured film according to claim 9 or 10 is disposed as an interlayer insulating film  
between substrates adjacent to each other, wherein said substrates are composed of  
two or more materials.