DESCRIPTION

Title of Invention:

# SEMICONDUCTOR ELEMENT-FORMING COMPOSITION

## Technical Field

[0001]

The present invention relates to a semiconductor element-forming composition applicable as a cavity-forming composition for forming a cavity between conductive wiring patterns, a protective film-forming composition for forming a protective film having excellent resistance to a wet etching solution for semiconductor use, or a resist underlayer film-forming composition for forming a resist underlayer film in a lithography process. The present invention also relates to a method for manufacturing a semiconductor element or a semiconductor device using a cured film formed from the semiconductor element-forming composition.

## Background Art

[0002]

With advances in semiconductor device technology in recent years, various coating-type organic materials are used in the process of forming circuits of semiconductor devices. The cavity-forming composition for forming a cavity between conductive wiring patterns, the protective

film-forming composition for forming a protective film having excellent resistance to a wet etching solution for semiconductor use, and the resist underlayer film-forming composition for forming a resist underlayer film in a lithography process are all the semiconductor element-forming compositions used in forming circuits of such semiconductor devices.

[0003]

A semiconductor element-forming composition used in forming circuits of semiconductor devices and the like is generally used as a cured film after undergoing a coating step of applying the composition onto various substrates including silicon and a baking step for curing the composition. In this regard, compositions capable of causing a chemical reaction that satisfies good coatability, film-curability in a short period of time, and storage stability are limited.

A composition containing an epoxy group is a promising composition that cures in a short period of time in the baking step.

On the other hand, a composition containing an epoxy group, a reactive group that reacts with the epoxy group, and a basic curing agent, the composition being diluted with various solvents commonly used in the semiconductor industry raises concerns about deterioration of storage

stability due to the reactivity of the basic curing agent.

[0004]

Incidentally, a technique for improving the pot life of a basic curing agent is known (see Patent Literature 1).

In addition, it is known that a basic curing agent having an imidazole structure is used after conversion into a salt with an acid (see Patent Literature 2).

However, none of these patent literatures describe storage stability of a composition used in forming circuits of semiconductor devices.

## Citation List

### Patent Literatures

[0005]

Patent Literature 1: JP 2020-514456 W

Patent Literature 2: JP H03-166221 A

## Summary of Invention

### Technical Problem

[0006]

A liquid composition used in forming semiconductor circuits and involving a coating step and a baking step is required to have high storage stability (meaning that film-curability and molecular weight distribution remain unchanged during long-term storage) due to industrial

demands.

[0007]

Accordingly, an object of the present invention is to provide a semiconductor element-forming composition used in forming circuits of semiconductor devices and the like, the semiconductor element-forming composition satisfying all of good coatability, film-curability in a short period of time, and good storage stability.

Solution to Problem

[0008]

As a result of extensive studies conducted to solve the above problems, the present inventors have found that, in order to inhibit side reactions that occur during storage and are caused by a reaction between a reactive group represented by a 3-membered or 4-membered cyclic ether structure having high reactivity and a reactive group having reactivity with respect to the reactive group, further adding an acidic additive as a stabilizer to a basic curing agent enables formation of a composition capable of satisfying high storage stability that can withstand the demands of the semiconductor manufacturing industry, and have thereby completed the present invention.

[0009]

That is, the present invention includes the following

aspects.

[1] A semiconductor element-forming composition containing:

(A) a compound or polymer having a reactive group represented by a cyclic ether structure represented by the following Formula (I);

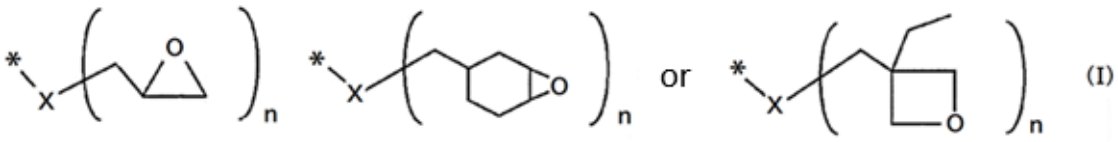
(B) a compound or polymer having a reactive group having reactivity with respect to the reactive group in (A);

(C) a basic curing agent;

(D) an acidic additive; and

(E) a solvent,

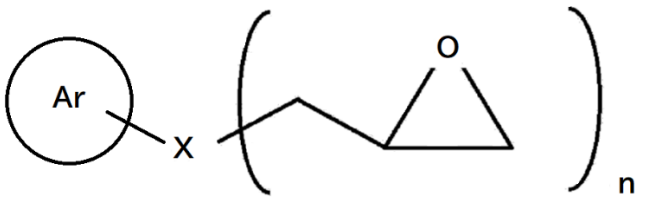
[Chem. 1]




wherein * indicates a bonding site; n represents 1 or 2; when n = 1, X represents an ether bond, an ester bond, or an amide bond; and when n = 2, X represents a nitrogen atom or an amide bond.

[2] The semiconductor element-forming composition according to [1], wherein the compound in (A) is a compound having a partial structure represented by the following Formula (III),

[Chem. 2]

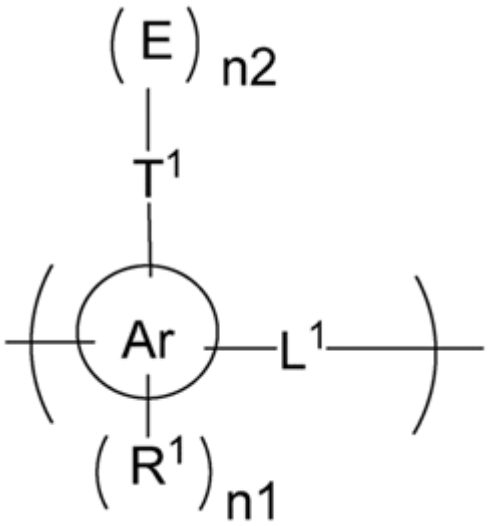



(III)

wherein Ar represents a benzene ring, a naphthalene ring, or an anthracene ring; n is 1 or 2; and when n = 1, X represents an ether bond, an ester bond, or an amide bond, and when n = 2, X represents a nitrogen atom or an amide bond.

[3] The semiconductor element-forming composition according to [1], wherein the polymer in (A) is a polymer having a novolac structure having a unit structure represented by the following Formula (1-1),

[Chem. 3]




Formula (1-1)

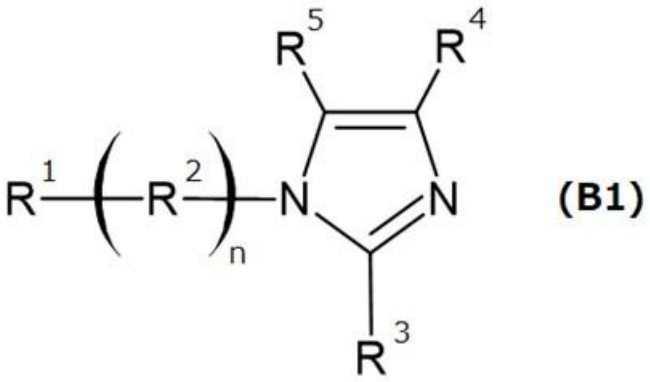
wherein Ar represents a benzene ring, a naphthalene ring, or an anthracene ring; $R^1$ represents a hydroxy group, a mercapto group which may be protected by a methyl group,

an amino group which may be protected by a methyl group, a halogeno group, or an alkyl group having 1 to 10 carbon atoms, which may be substituted with or interrupted by a heteroatom and may be substituted with a hydroxy group; n1 represents an integer of 0 to 3; $L^1$ represents a single bond or an alkylene group having 1 to 10 carbon atoms; n2 represents 1 or 2; E represents a group having an epoxy group or a group having an oxetanyl group; when n2 = 1, $T^1$ represents an alkylene group having 1 to 10 carbon atoms, which may be interrupted by an ether bond, an ester bond, or an amide bond; and when n2 = 2, $T^1$ represents a trivalent hydrocarbon group having 1 to 10 carbon atoms, which may be interrupted by a nitrogen atom or an amide bond.

[4] The semiconductor element-forming composition according to any one of [1] to [3], wherein the compound or polymer in (B) is a compound or polymer having a phenolic hydroxy group, or a compound having a thiol structure.

[5] The semiconductor element-forming composition according to any one of [1] to [4], wherein the basic curing agent in (C) is a compound represented by the following Formula (B1),

[Chem. 4]

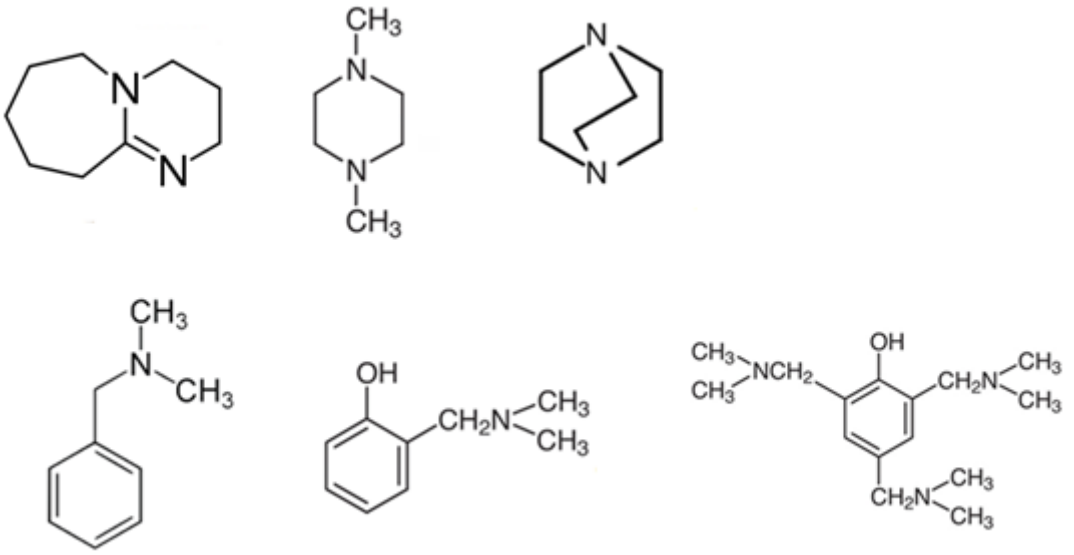


(B1)

wherein $R^1$ represents a hydrogen atom, an alkyl group having 1 to 4 carbon atoms, an aryl group which may be substituted, a monovalent group obtained by removing, from a triazine ring which may be substituted, a hydrogen atom bonded to a carbon atom of the triazine ring, a cyano group, a hydroxy group, an amino group, a vinyl group, an acryloyloxy group, or a methacryloyloxy group; $R^2$ represents an alkylene group having 1 to 4 carbon atoms; $R^3$ represents a hydrogen atom, an alkyl group having 1 to 17 carbon atoms, or an aryl group which may be substituted; $R^4$ represents a hydrogen atom, a formyl group, an alkyl group having 1 to 4 carbon atoms, which may be substituted, or an alkoxyalkyl group having 4 or less carbon atoms, which may be substituted; $R^5$ represents a hydrogen atom, a formyl group, an alkyl group having 1 to 4 carbon atoms, which may be substituted, or an alkoxyalkyl group having 4 or less carbon atoms, which may be substituted; and n represents 0 or 1.

[6] The semiconductor element-forming composition according to any one of [1] to [4], wherein the basic curing agent in (C) is at least one compound selected from the group consisting of tertiary amine compounds represented by the following formulae.

[Chem. 5]



[7] The semiconductor element-forming composition according to any one of [1] to [6], wherein the acidic additive in (D) is a compound containing at least one group selected from an imide group, a carboxy group, a sulfonyl group, and a sulfo group.

[8] The semiconductor element-forming composition according to [7], wherein the acidic additive in (D) is acetic acid or maleic acid.

[9] The semiconductor element-forming composition

according to any one of [1] to [8], wherein the solvent in (E) includes at least one solvent selected from the group consisting of propylene glycol monomethyl ether, propylene glycol, monomethyl ether acetate, isopropyl alcohol, ethyl acetate, butyl acetate, and cyclohexanone.

[10] The semiconductor element-forming composition according to any one of [1] to [9], wherein the semiconductor element-forming composition is used as a cavity-forming composition for forming a cavity between conductive wiring patterns.

[11] The semiconductor element-forming composition according to any one of [1] to [9], wherein the semiconductor element-forming composition is used as a protective film-forming composition for forming a protective film having excellent resistance to a wet etching solution for semiconductor use.

[12] The semiconductor element-forming composition according to any one of [1] to [9], wherein the semiconductor element-forming composition is used as a resist underlayer film-forming composition in a lithography process.

[13] A semiconductor element-forming film that is a baked product of a coating film composed of the semiconductor element-forming composition according to any one of [1] to [12].

## Advantageous Effects of Invention

[0010]

According to the present invention, it is possible to provide the semiconductor element-forming composition used in forming circuits of semiconductor devices and the like, the semiconductor element-forming composition satisfying all of good coatability, film-curability in a short period of time, and good storage stability.

## Description of Embodiments

[0011]

Hereinafter, the present invention will be described in detail. Note that the description of the constituent requirements described below is an example for describing the present invention, and the present invention is not limited to the content thereof.

[0012]

(Semiconductor Element-Forming Composition)

A semiconductor element-forming composition of the present invention contains:

(A) a compound or polymer having a reactive group represented by a cyclic ether structure represented by the following Formula (I);

(B) a compound having a reactive group having

reactivity with respect to the reactive group in (A);

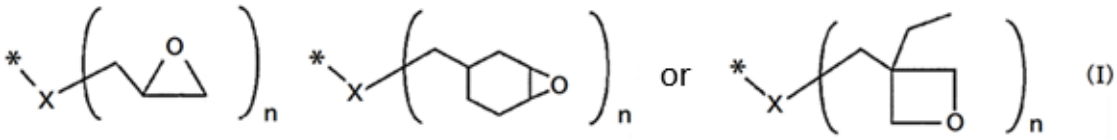
(C) a basic curing agent;

(D) an acidic additive; and

(E) a solvent,

[0013]

[Chem. 6]



in Formula (I), * represents a bonding site; n represents 1 or 2; and when n = 1, X represents an ether bond, an ester bond, or an amide bond, and when n = 2, X represents a nitrogen atom or an amide bond.

[0014]

The semiconductor element-forming composition of the present invention may further contain, as other components, a compound having a hydroxy group and at least one of a hydroxy group and a carbonyl group.

[0015]

The present inventors have found that a semiconductor element-forming composition containing (A) a compound or polymer having a cyclic ether structure represented by the above Formula (I), (B) a compound having a reactive group having reactivity with respect to the reactive group in (A), (C) a basic curing agent, (D) an acidic additive, and

(E) a solvent is capable of satisfying all of good coatability, film-curability in a short period of time, and good storage stability. The semiconductor element-forming composition can be suitably used as a cavity-forming composition for forming a cavity between conductive wiring patterns, a protective film-forming composition for forming a protective film having excellent resistance to a wet etching solution for semiconductor use, a resist underlayer film-forming composition in a lithography process (particularly a resist underlayer film-forming composition having an antireflection function), and the like.

[0016]

<(A) Compound or Polymer>

The compound or polymer (A) used in the present invention has a reactive group represented by a cyclic ether structure (an epoxy structure or an oxetane structure) represented by the above Formula (I).

Examples of more preferred embodiments of the compound or polymer (A) include a polymer represented by the following first aspect and a compound represented by the following second aspect.

[0017]

<<First Aspect>>

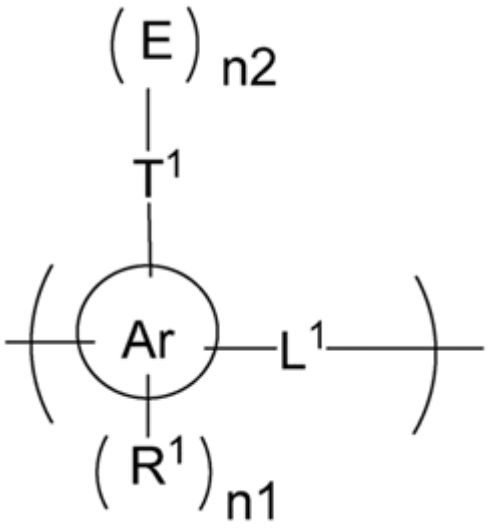
Examples of the polymer (A) used in the present invention include the following polymers.

Examples of such a polymer (hereinafter also referred to as a polymer in the first aspect) include a polymer having a novolac structure having a unit structure represented by the following Formula (1-1) and an acrylic polymer having a unit structure represented by the following Formula (1-3).

[0018]

As the polymer in the first aspect, for example, a polymer having a novolac structure is represented by the following formula (1-1).

[Chem. 7]




Formula (1-1)

In Formula (1-1), Ar represents a benzene ring, a naphthalene ring, or an anthracene ring, $R^1$ represents a hydroxy group, a mercapto group which may be protected by a methyl group, an amino group which may be protected by a methyl group, a halogeno group, or an alkyl group having 1 to 10 carbon atoms, which may be substituted with or

interrupted by a heteroatom and may be substituted with a hydroxy group, n1 represents an integer of 0 to 3, $L^1$ represents a single bond or an alkylene group having 1 to 10 carbon atoms, n2 represents 1 or 2, E represents a group having an epoxy group or a group having an oxetanyl group, $T^1$ represents an alkylene group having 1 to 10 carbon atoms, which may be interrupted by an ether bond, an ester bond, or an amide bond when n2 = 1, and $T^1$ represents a trivalent hydrocarbon group having 1 to 10 carbon atoms, which may be interrupted by a nitrogen atom or an amide bond when n2 = 2.

[0019]

Examples of the alkyl group having 1 to 10 carbon atoms include a methyl group, an ethyl group, an n-propyl group, an i-propyl group, a cyclopropyl group, an n-butyl group, an i-butyl group, an s-butyl group, a t-butyl group, a cyclobutyl group, a 1-methyl-cyclopropyl group, a 2-methyl-cyclopropyl group, an n-pentyl group, a 1-methyl-n-butyl group, a 2-methyl-n-butyl group, a 3-methyl-n-butyl group, a 1,1-dimethyl-n-propyl group, a 1,2-dimethyl-n-propyl group, a 2,2-dimethyl-n-propyl group, a 1-ethyl-n-propyl group, a cyclopentyl group, a 1-methyl-cyclobutyl group, a 2-methyl-cyclobutyl group, a 3-methyl-cyclobutyl group, a 1,2-dimethyl-cyclopropyl group, a 2,3-dimethyl-cyclopropyl group, a 1-ethyl-cyclopropyl group, a 2-ethyl-cyclopropyl

group, an n-hexyl group, a 1-methyl-n-pentyl group, a 2-methyl-n-pentyl group, a 3-methyl-n-pentyl group, a 4-methyl-n-pentyl group, a 1,1-dimethyl-n-butyl group, a 1,2-dimethyl-n-butyl group, a 1,3-dimethyl-n-butyl group, a 2,2-dimethyl-n-butyl group, a 2,3-dimethyl-n-butyl group, a 3,3-dimethyl-n-butyl group, a 1-ethyl-n-butyl group, a 2-ethyl-n-butyl group, a 1,1,2-trimethyl-n-propyl group, a 1,2,2-trimethyl-n-propyl group, a 1-ethyl-1-methyl-n-propyl group, a 1-ethyl-2-methyl-n-propyl group, a cyclohexyl group, a 1-methyl-cyclopentyl group, a 2-methyl-cyclopentyl group, a 3-methyl-cyclopentyl group, a 1-ethyl-cyclobutyl group, a 2-ethyl-cyclobutyl group, a 3-ethyl-cyclobutyl group, a 1,2-dimethyl-cyclobutyl group, a 1,3-dimethyl-cyclobutyl group, a 2,2-dimethyl-cyclobutyl group, a 2,3-dimethyl-cyclobutyl group, a 2,4-dimethyl-cyclobutyl group, a 3,3-dimethyl-cyclobutyl group, a 1-n-propyl-cyclopropyl group, a 2-n-propyl-cyclopropyl group, a 1-i-propyl-cyclopropyl group, a 2-i-propyl-cyclopropyl group, a 1,2,2-trimethyl-cyclopropyl group, a 1,2,3-trimethyl-cyclopropyl group, a 2,2,3-trimethyl-cyclopropyl group, a 1-ethyl-2-methyl-cyclopropyl group, a 2-ethyl-1-methyl-cyclopropyl group, a 2-ethyl-2-methyl-cyclopropyl group, a 2-ethyl-3-methyl-cyclopropyl group, a decyl group, a methoxy group, an ethoxy group, a methoxymethyl group, an ethoxymethyl group, a methoxyethyl group, an ethoxyethyl group, a

hydroxymethyl group, a 1-hydroxyethyl group, a 2-hydroxyethyl group, a methylamino group, a dimethylamino group, a diethylamino group, an aminomethyl group, a 1-aminoethyl group, a 2-aminoethyl group, a methylthio group, an ethylthio group, a mercaptomethyl group, a 1-mercaptoethyl group, and a 2-mercaptoethyl group.

[0020]

Examples of the alkylene group having 1 to 10 carbon atoms include a methylene group, an ethylene group, an n-propylene group, an isopropylene group, a cyclopropylene group, an n-butylene group, an isobutylene group, an s-butylene group, a t-butylene group, a cyclobutylene group, a 1-methyl-cyclopropylene group, a 2-methyl-cyclopropylene group, an n-pentylene group, a 1-methyl-n-butylene group, a 2-methyl-n-butylene group, a 3-methyl-n-butylene group, a 1,1-dimethyl-n-propylene group, a 1,2-dimethyl-n-propylene group, a 2,2-dimethyl-n-propylene group, a 1-ethyl-n-propylene group, a cyclopentylene group, a 1-methyl-cyclobutylene group, a 2-methyl-cyclobutylene group, a 3-methyl-cyclobutylene group, a 1,2-dimethyl-cyclopropylene group, a 2,3-dimethyl-cyclopropylene group, a 1-ethyl-cyclopropylene group, a 2-ethyl-cyclopropylene group, an n-hexylene group, a 1-methyl-n-pentylene group, a 2-methyl-n-pentylene group, a 3-methyl-n-pentylene group, a 4-methyl-n-pentylene group, a 1,1-dimethyl-n-butylene group, a 1,2-

dimethyl-n-butylene group, a 1,3-dimethyl-n-butylene group, a 2,2-dimethyl-n-butylene group, a 2,3-dimethyl-n-butylene group, a 3,3-dimethyl-n-butylene group, a 1-ethyl-n-butylene group, a 2-ethyl-n-butylene group, a 1,1,2-trimethyl-n-propylene group, a 1,2,2-trimethyl-n-propylene group, a 1-ethyl-1-methyl-n-propylene group, a 1-ethyl-2-methyl-n-propylene group, a cyclohexylene group, a 1-methyl-cyclopentylene group, a 2-methyl-cyclopentylene group, a 3-methyl-cyclopentylene group, a 1-ethyl-cyclobutylene group, a 2-ethyl-cyclobutylene group, a 3-ethyl-cyclobutylene group, a 1,2-dimethyl-cyclobutylene group, a 1,3-dimethyl-cyclobutylene group, a 2,2-dimethyl-cyclobutylene group, a 2,3-dimethyl-cyclobutylene group, a 2,4-dimethyl-cyclobutylene group, a 3,3-dimethyl-cyclobutylene group, a 1-n-propyl-cyclopropylene group, a 2-n-propyl-cyclopropylene group, a 1-isopropyl-cyclopropylene group, a 2-isopropyl-cyclopropylene group, a 1,2,2-trimethyl-cyclopropylene group, a 1,2,3-trimethyl-cyclopropylene group, a 2,2,3-trimethyl-cyclopropylene group, a 1-ethyl-2-methyl-cyclopropylene group, a 2-ethyl-1-methyl-cyclopropylene group, a 2-ethyl-2-methyl-cyclopropylene group, a 2-ethyl-3-methyl-cyclopropylene group, an n-heptylene group, an n-octylene group, an n-nonylene group, and an n-decanylene group.

[0021]

An example of the alkyl group having 1 to 10 carbon atoms which is substituted with or interrupted by a heteroatom in $R^1$ is an alkoxy group having 1 to 10 carbon atoms.

[0022]

Examples of the alkoxy group having 1 to 10 carbon atoms include a methoxy group, an ethoxy group, an n-propoxy group, an i-propoxy group, an n-butoxy group, an i-butoxy group, an s-butoxy group, a t-butoxy group, an n-pentoxy group, a 1-methyl-n-butoxy group, a 2-methyl-n-butoxy group, a 3-methyl-n-butoxy group, a 1,1-dimethyl-n-propoxy group, a 1,2-dimethyl-n-propoxy group, a 2,2-dimethyl-n-propoxy group, a 1-ethyl-n-propoxy group, an n-hexyloxy group, a 1-methyl-n-pentyloxy group, a 2-methyl-n-pentyloxy group, a 3-methyl-n-pentyloxy group, a 4-methyl-n-pentyloxy group, a 1,1-dimethyl-n-butoxy group, a 1,2-dimethyl-n-butoxy group, a 1,3-dimethyl-n-butoxy group, a 2,2-dimethyl-n-butoxy group, a 2,3-dimethyl-n-butoxy group, a 3,3-dimethyl-n-butoxy group, a 1-ethyl-n-butoxy group, a 2-ethyl-n-butoxy group, a 1,1,2-trimethyl-n-propoxy group, a 1,2,2-trimethyl-n-propoxy group, a 1-ethyl-1-methyl-n-propoxy group, a 1-ethyl-2-methyl-n-propoxy group, an n-heptyloxy group, an n-octyloxy group, and an n-nonyloxy group.

[0023]

The unit structure represented by Formula (1-1) may be one kind or a combination of two or more kinds. For example, a copolymer having a plurality of unit structures in which Ar is the same kind may be used, and for example, a copolymer having a plurality of unit structures in which Ar is different in kind, such as a copolymer having a unit structure in which Ar has a benzene ring and having a unit structure having a naphthalene ring, is not excluded from the technical scope of the present application.

[0024]

The phrase "may be interrupted" means that in the case of an alkylene group having 2 to 10 carbon atoms, any carbon-carbon bond in the alkylene group is interrupted by a heteroatom (that is, an ether bond in the case of oxygen, and a sulfide bond in the case of sulfur), an ester bond, or an amide bond, and in the case of one carbon atom (that is, a methylene group), the carbon of the methylene group has, on either side thereof, a heteroatom (that is, an ether bond in the case of oxygen, and a sulfide bond in the case of sulfur), an ester bond, or an amide bond.

[0025]

$T^1$ represents a hydrocarbon group having 1 to 10 carbon atoms (including an alkylene group and a trivalent hydrocarbon group), which may be interrupted by an ether bond, an ester bond, a nitrogen atom, or an amide bond, and

is preferably a combination of an ether bond and a methylene group (that is, when "-$T^1$-(E)n2" in Formula (1-1) is a glycidyl ether group), a combination of an ester bond and a methylene group, or a combination of an amide bond and a methylene group.

[0026]

The alkyl group having 1 to 10 carbon atoms, which may be substituted with a heteroatom, means that one or more hydrogen atoms of the alkyl group having 1 to 10 carbon atoms are substituted with a heteroatom (preferably a halogeno group).

[0027]

$L^1$ represents a single bond or an alkylene group having 1 to 10 carbon atoms, and is preferably represented by the following Formula (1-2):

[Chem. 8]



Formula (1-2)

in Formula (1-2), $R^2$ and $R^3$ each independently represent a hydrogen atom, a methyl group, an ethyl group, a n-propyl group, an i-propyl group, a cyclopropyl group, a n-butyl group, an i-butyl group, a s-butyl group, a t-butyl group, or a cyclobutyl group, and $R^2$ and $R^3$ may be bonded to each other to form a ring having 3 to 6 carbon atoms. Among these, both $R^2$ and $R^3$ are preferably hydrogen atoms

(that is, $-(CR^2R^3)-$ is a methylene group).

[0028]

The halogeno group refers to a halogen -X (F, Cl, Br, or I) substituted for hydrogen.

[0029]

E in Formula (1-1) is more preferably a group having an epoxy group.

[0030]

The polymer having a novolac structure in the first aspect is not particularly limited as long as it satisfies, for example, the unit structure of Formula (1-1). The polymer may be produced by a known method. A commercially available product may also be used. Examples of the commercially available product include a heat-resistant epoxy novolac resin EOCN (registered trademark) series (manufactured by Nippon Kayaku Co., Ltd.), and an epoxy novolac resin D.E.N (registered trademark) series (manufactured by Dow Chemical Japan, Ltd.).

[0031]

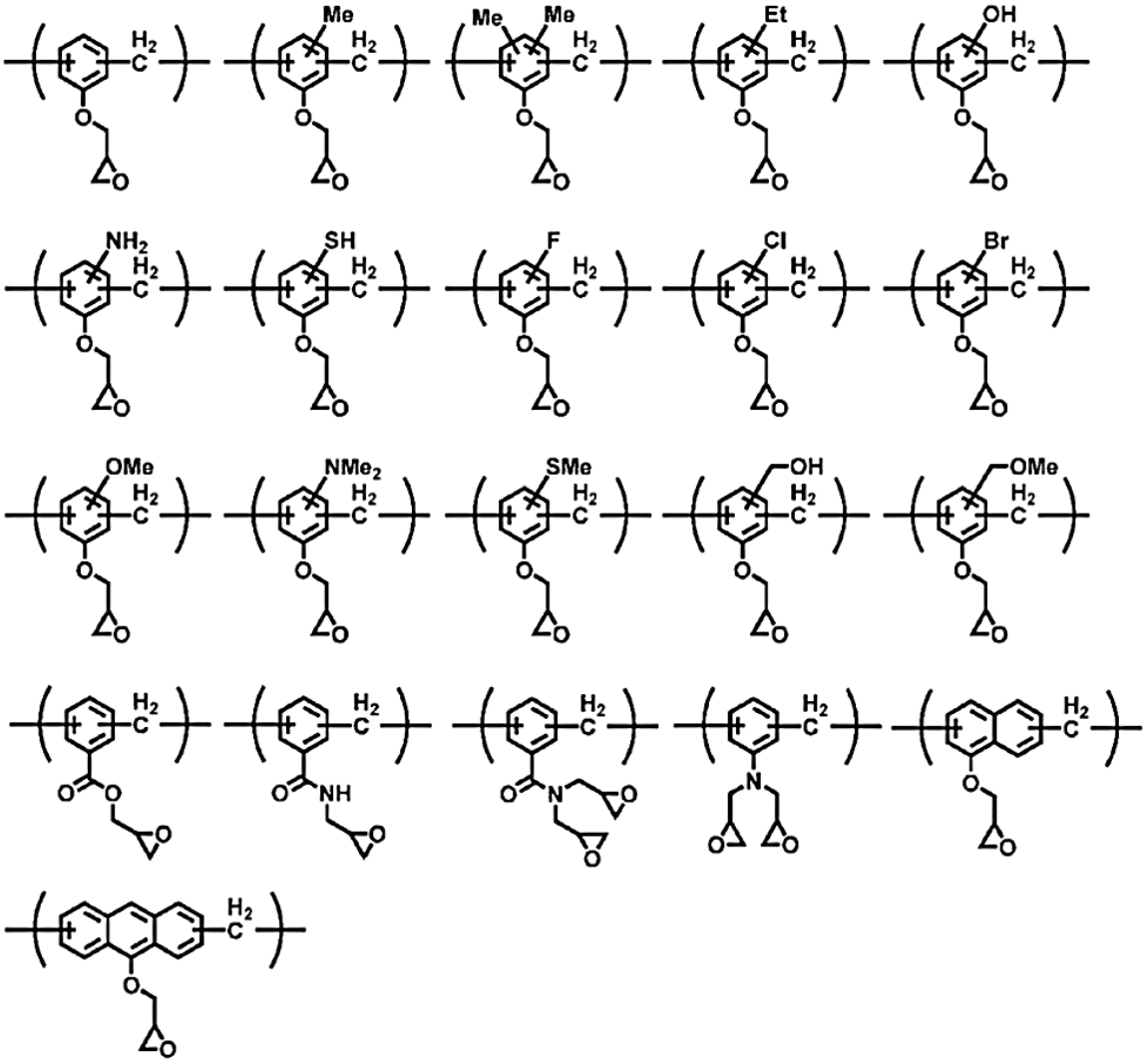
A weight-average molecular weight of the polymer having a novolac structure in the first aspect is 100 or more, 500 to 200,000, 600 to 50,000, or 700 to 10,000.

[0032]

Examples of the polymer having a novolac structure in the first aspect include those having the following unit

structure.

[Chem. 9]

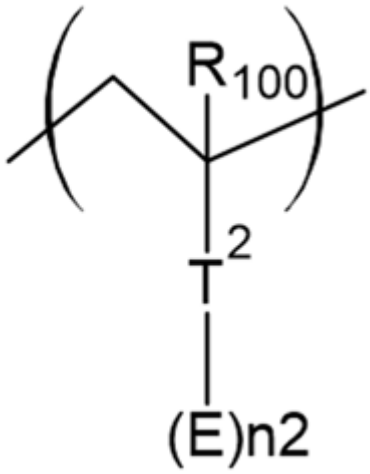


Me represents a methyl group, and Et represents an ethyl group.

[0033]

As the polymer in the first aspect, for example, the acrylic polymer is represented by the following Formula (1-3),

[Chem. 10]




Formula (1-3)

in Formula (1-3), $R_{100}$ represents a hydrogen atom or a methyl group, n2 represents 1 or 2, E represents a group having an epoxy group or a group having an oxetanyl group, $T^2$ represents an alkylene group having 1 to 10 carbon atoms, which may be interrupted by an ether bond, an ester bond, or an amide bond when n2 = 1, and $T^2$ represents a trivalent hydrocarbon group having 1 to 10 carbon atoms, which may be interrupted by a nitrogen atom or an amide bond when n2 = 2.

[0034]

A weight-average molecular weight of the acrylic polymer in the first aspect is 100 to 20,000, 300 to 10,000, or 500 to 5,000.

[0035]

<<Second Aspect>>

Examples of the compound (A) used in the present invention include the following compounds.

Such a compound (hereinafter also referred to as a compound in the second aspect) is a compound having no repeating structural unit,

the compound has a terminal group (A1), a polyvalent group (A2), and a linking group (A3),

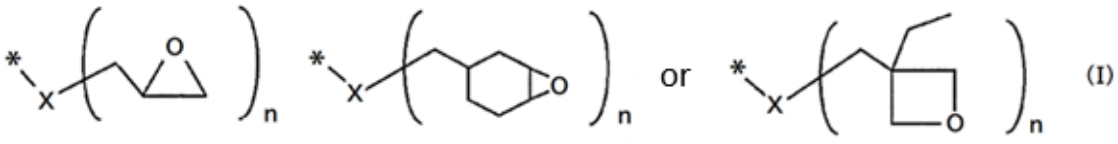
the terminal group (A1) is bonded only to the linking group (A3),

the polyvalent group (A2) is bonded only to the linking group (A3),

the linking group (A3) is bonded on one hand to the terminal group (A1) and on the other hand to the polyvalent group (A2), and may optionally be bonded to another linking group (A3),

the terminal group (A1) has any of structures of the following Formula (I),

[Chem. 11]




in Formula (I), * represents a bonding site with the linking group (A3); n represents 1 or 2; and when n = 1, X represents an ether bond, an ester bond, or an amide bond, and when n = 2, X represents a nitrogen atom or an amide bond,

the polyvalent group (A2) is a divalent to tetravalent

group selected from the group consisting of:

-O-;

an aliphatic hydrocarbon group;

a combination of an aromatic hydrocarbon group having less than 10 carbon atoms and an aliphatic hydrocarbon group; and

a combination of an aromatic hydrocarbon group having 10 or more carbon atoms and -O-, and

the linking group (A3) represents an aromatic hydrocarbon group.

[0036]

The phrase “having no repeating structural unit” means to exclude a so-called polymer having a repeating structural unit, such as a polyolefin, a polyester, a polyamide, or a poly(meth)acrylate. The weight-average molecular weight of the compound (A) is preferably 300 or more and 1,500 or less.

[0037]

The “bond” between the terminal group (A1), the polyvalent group (A2), and the linking group (A3) means a chemical bond, and this usually means a covalent bond but does not preclude an ionic bond.

[0038]

The polyvalent group (A2) is a divalent to tetravalent group.

[0039]

Therefore, the aliphatic hydrocarbon group in the definition of the polyvalent group (A2) is a divalent to tetravalent aliphatic hydrocarbon group.

Non-limiting examples of the divalent aliphatic hydrocarbon group include alkylene groups such as a methylene group, an ethylene group, an n-propylene group, an isopropylene group, a cyclopropylene group, an n-butylene group, an isobutylene group, an s-butylene group, a t-butylene group, a cyclobutylene group, a 1-methyl-cyclopropylene group, a 2-methyl-cyclopropylene group, an n-pentylene group, a 1-methyl-n-butylene group, a 2-methyl-n-butylene group, a 3-methyl-n-butylene group, a 1,1-dimethyl-n-propylene group, a 1,2-dimethyl-n-propylene group, a 2,2-dimethyl-n-propylene group, a 1-ethyl-n-propylene group, a cyclopentylene group, a 1-methyl-cyclobutylene group, a 2-methyl-cyclobutylene group, a 3-methyl-cyclobutylene group, a 1,2-dimethyl-cyclopropylene group, a 2,3-dimethyl-cyclopropylene group, a 1-ethyl-cyclopropylene group, a 2-ethyl-cyclopropylene group, an n-hexylene group, a 1-methyl-n-pentylene group, a 2-methyl-n-pentylene group, a 3-methyl-n-pentylene group, a 4-methyl-n-pentylene group, a 1,1-dimethyl-n-butylene group, a 1,2-dimethyl-n-butylene group, a 1,3-dimethyl-n-butylene group, a 2,2-dimethyl-n-butylene group, a 2,3-dimethyl-n-butylene

group, a 3,3-dimethyl-n-butylene group, a 1-ethyl-n-butylene group, a 2-ethyl-n-butylene group, a 1,1,2-trimethyl-n-propylene group, a 1,2,2-trimethyl-n-propylene group, a 1-ethyl-1-methyl-n-propylene group, a 1-ethyl-2-methyl-n-propylene group, a cyclohexylene group, a 1-methyl-cyclopentylene group, a 2-methyl-cyclopentylene group, a 3-methyl-cyclopentylene group, a 1-ethyl-cyclobutylene group, a 2-ethyl-cyclobutylene group, a 3-ethyl-cyclobutylene group, a 1,2-dimethyl-cyclobutylene group, a 1,3-dimethyl-cyclobutylene group, a 2,2-dimethyl-cyclobutylene group, a 2,3-dimethyl-cyclobutylene group, a 2,4-dimethyl-cyclobutylene group, a 3,3-dimethyl-cyclobutylene group, a 1-n-propyl-cyclopropylene group, a 2-n-propyl-cyclopropylene group, a 1-isopropyl-cyclopropylene group, a 2-isopropyl-cyclopropylene group, a 1,2,2-trimethyl-cyclopropylene group, a 1,2,3-trimethyl-cyclopropylene group, a 2,2,3-trimethyl-cyclopropylene group, a 1-ethyl-2-methyl-cyclopropylene group, a 2-ethyl-1-methyl-cyclopropylene group, a 2-ethyl-2-methyl-cyclopropylene group, a 2-ethyl-3-methyl-cyclopropylene group, an n-heptylene group, an n-octylene group, an n-nonylene group, and an n-decanylene group.

[0040]

When hydrogen at any site is removed from these groups, and the site is converted into a linking bond, trivalent

and tetravalent groups are derived.

[0041]

Examples of the aromatic hydrocarbon group having less than 10 carbon atoms in the definition of the polyvalent group (A2) include benzene, toluene, xylene, mesitylene, cumene, styrene, and indene.

[0042]

Examples of the aliphatic hydrocarbon group that is combined with the aromatic hydrocarbon group having less than 10 carbon atoms include, in addition to the above-described alkylene groups, alkyl groups such as a methyl group, an ethyl group, an n-propyl group, an i-propyl group, a cyclopropyl group, an n-butyl group, an i-butyl group, an s-butyl group, a t-butyl group, a cyclobutyl group, a 1-methyl-cyclopropyl group, a 2-methyl-cyclopropyl group, an n-pentyl group, a 1-methyl-n-butyl group, a 2-methyl-n-butyl group, a 3-methyl-n-butyl group, a 1,1-dimethyl-n-propyl group, a 1,2-dimethyl-n-propyl group, a 2,2-dimethyl-n-propyl group, a 1-ethyl-n-propyl group, a cyclopentyl group, a 1-methyl-cyclobutyl group, a 2-methyl-cyclobutyl group, a 3-methyl-cyclobutyl group, a 1,2-dimethyl-cyclopropyl group, a 2,3-dimethyl-cyclopropyl group, a 1-ethyl-cyclopropyl group, a 2-ethyl-cyclopropyl group, an n-hexyl group, a 1-methyl-n-pentyl group, a 2-methyl-n-pentyl group, a 3-methyl-n-pentyl group, a 4-

methyl-n-pentyl group, a 1,1-dimethyl-n-butyl group, a 1,2-dimethyl-n-butyl group, a 1,3-dimethyl-n-butyl group, a 2,2-dimethyl-n-butyl group, a 2,3-dimethyl-n-butyl group, a 3,3-dimethyl-n-butyl group, a 1-ethyl-n-butyl group, a 2-ethyl-n-butyl group, a 1,1,2-trimethyl-n-propyl group, a 1,2,2-trimethyl-n-propyl group, a 1-ethyl-1-methyl-n-propyl group, a 1-ethyl-2-methyl-n-propyl group, a cyclohexyl group, a 1-methyl-cyclopentyl group, a 2-methyl-cyclopentyl group, a 3-methyl-cyclopentyl group, a 1-ethyl-cyclobutyl group, a 2-ethyl-cyclobutyl group, a 3-ethyl-cyclobutyl group, a 1,2-dimethyl-cyclobutyl group, a 1,3-dimethyl-cyclobutyl group, a 2,2-dimethyl-cyclobutyl group, a 2,3-dimethyl-cyclobutyl group, a 2,4-dimethyl-cyclobutyl group, a 3,3-dimethyl-cyclobutyl group, a 1-n-propyl-cyclopropyl group, a 2-n-propyl-cyclopropyl group, a 1-i-propyl-cyclopropyl group, a 2-i-propyl-cyclopropyl group, a 1,2,2-trimethyl-cyclopropyl group, a 1,2,3-trimethyl-cyclopropyl group, a 2,2,3-trimethyl-cyclopropyl group, a 1-ethyl-2-methyl-cyclopropyl group, a 2-ethyl-1-methyl-cyclopropyl group, a 2-ethyl-2-methyl-cyclopropyl group, a 2-ethyl-3-methyl-cyclopropyl group, and a decyl group.

[0043]

Any of the aromatic hydrocarbon group having less than 10 carbon atoms and the aliphatic hydrocarbon group in the definition of the polyvalent group (A2) may be bonded to

the linking group (A3).

[0044]

Examples of the aromatic hydrocarbon group having 10 or more carbon atoms in the definition of the polyvalent group (A2) include naphthalene, azulene, anthracene, phenanthrene, naphthacene, triphenylene, pyrene, and chrysene.

[0045]

It is preferable that the aromatic hydrocarbon group having 10 or more carbon atoms in the definition of the polyvalent group (A2) is bonded to the linking group (A3) through -O-.

[0046]

Examples of the aromatic hydrocarbon group in the definition of the linking group (A3) include the above-described aromatic hydrocarbon group having less than 10 carbon atoms and the above-described aromatic hydrocarbon group having 10 or more carbon atoms.

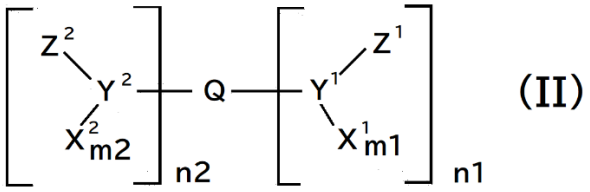
[0047]

Preferably, the compound (A) has two or more linking groups (A3).

[0048]

The compound in the second aspect is preferably represented by, for example, the following formula (II).

[Chem. 12]

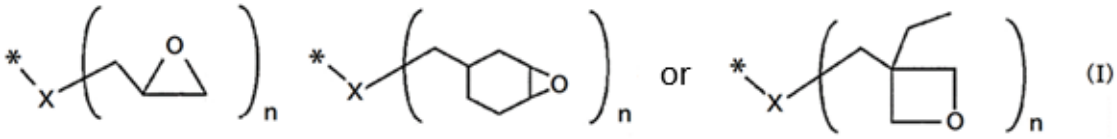


(II)

In Formula (II),

$Z^1$ and $Z^2$ each independently represent

[Chem. 13]



(I)

in Formula (I), * represents $Y^1$ or a bonding site with $Y^2$; n represents 1 or 2; and when n = 1, X represents an ether bond, an ester bond, or an amide bond, and when n = 2, X represents a nitrogen atom or an amide bond,

$Y^1$ and $Y^2$ each independently represent an aromatic hydrocarbon group,

$X^1$ and $X^2$ each independently represent $-Y^1-Z^1$ or $-Y^2-Z^2$,

n1 and n2 each independently represent an integer of 0 to 4, where any one of n1 and n2 is 1 or more,

m1 defined in $(X^1)m1$ represents 0 or 1,

m2 defined in $(X^2)m2$ represents 0 or 1, and

Q represents a (n1 + n2)-valent group selected from the group consisting of -O-, an aliphatic hydrocarbon group, a combination of an aromatic hydrocarbon group having less than 10 carbon atoms and an aliphatic hydrocarbon group,

and a combination of an aromatic hydrocarbon group having 10 or more carbon atoms and -O-.

It is preferable that Q is a divalent to tetravalent group.

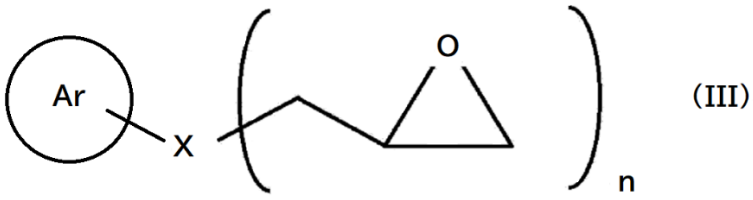
[0049]

In Formula (II), $Z^1$ and $Z^2$ correspond to the terminal group (A1), Q corresponds to the polyvalent group (A2), $Y^1$ and $Y^2$ correspond to the linking group (A3), and the description, examples, and the like thereof are as described above.

[0050]

The compound in the second aspect preferably has a partial structure represented by, for example, the following Formula (III),

[Chem. 14]



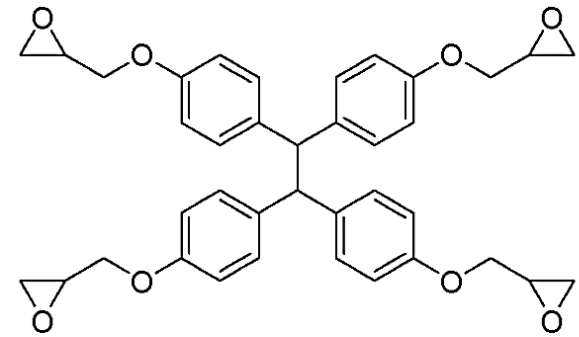

(III)

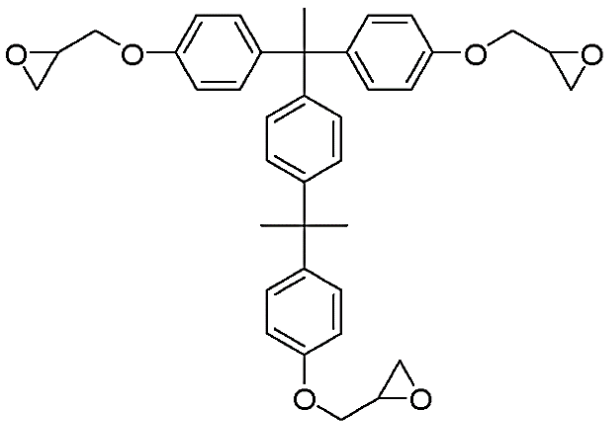
in Formula (III), Ar represents a benzene ring, a naphthalene ring, or an anthracene ring; n represents 1 or 2; and when n = 1, X represents an ether bond, an ester bond, or an amide bond, and when n = 2, X represents a nitrogen atom or an amide bond.

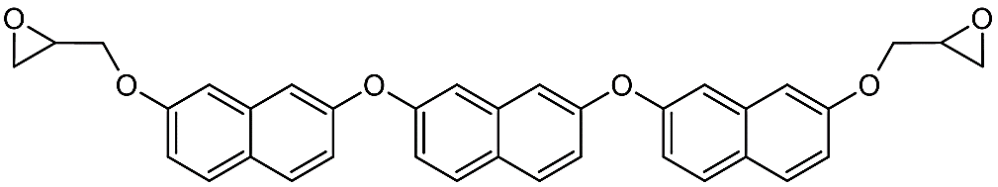
[0051]

Examples of the compound in the second aspect include the following compounds.

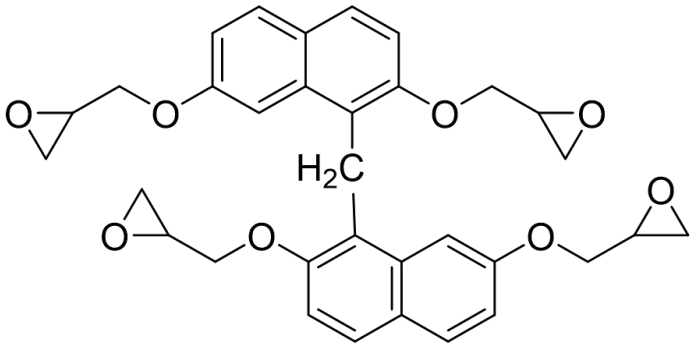
[Chem. 15]



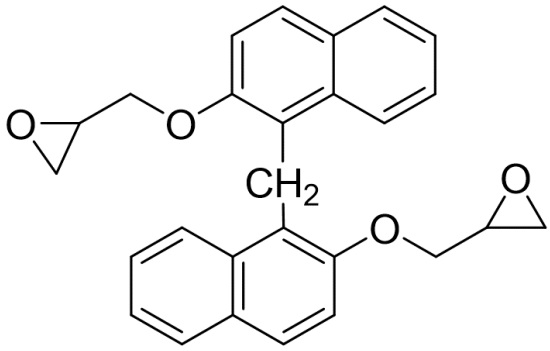




[Chem. 16]



[Chem. 17]



[0052]

<(B) Compound or Polymer Having Reactive Group Having Reactivity with Respect to Reactive Group in (A)>

The compound or polymer (B) used in the present invention has a reactive group having reactivity with respect to the reactive group in (A).

More preferred embodiments of the compound or polymer (B) include a compound or polymer having a phenolic hydroxy group as shown in a third aspect described below, or a compound having a thiol structure as shown in a fourth aspect, and the like.

[0053]

<<Third Aspect>>

Examples of the compound or polymer (B) used in the present invention include the following compounds or polymers having a phenolic hydroxy group.

The compound or polymer having a phenolic hydroxy group (B) is not particularly limited as long as it is a compound or polymer that does not impair the effect of the present invention. Needless to say, the compound or polymer having a phenolic hydroxy group (B) is different from the compound or polymer (A).

[0054]

A weight-average molecular weight of the compound or polymer having a phenolic hydroxy group (B) (hereinafter also referred to as the compound or polymer (B)) is also not particularly limited, and is, for example, 300 to 50,000.

[0055]

The compound or polymer (B) preferably has two or more phenolic hydroxy groups.

More preferred embodiments of the compound or polymer (B) include, for example, compounds or polymers as shown in Aspect 3-1 to Aspect 3-3 described below.

[0056]

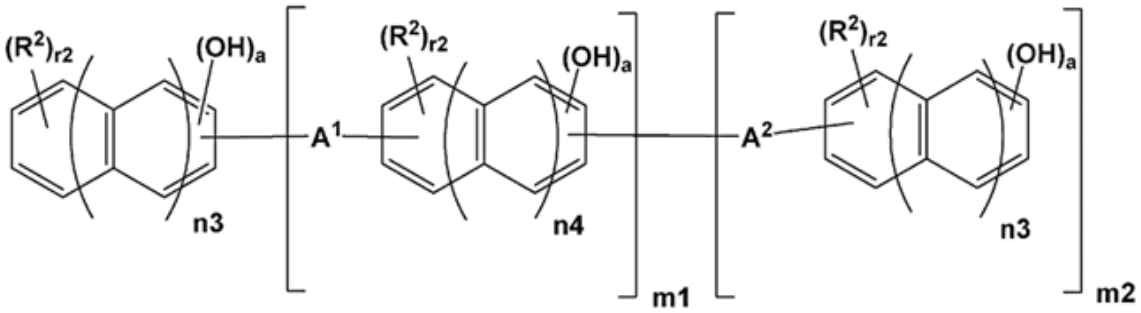
<<Aspect 3-1>>

Examples of the compound or polymer (B) used in the

present invention include a compound or polymer represented by (Formula 2-1).

[0057]

[Chem. 18]



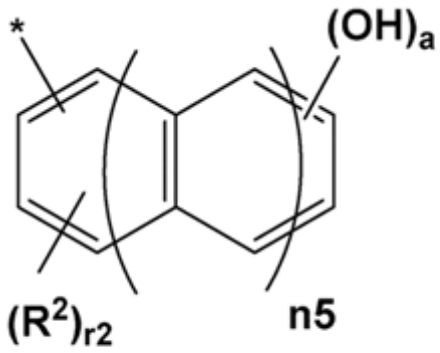

(Formula 2-1)

In the formula, $R^2$s each independently represent a halogeno group, a carboxy group, a nitro group, a cyano group, a methylenedioxy group, an acetoxy group, a methylthio group, an alkoxy group having 1 to 9 carbon atoms, an amino group which may be substituted with an alkyl group having 1 to 3 carbon atoms, or an alkyl group having 1 to 10 carbon atoms, which may be substituted with a hydroxy group or a halogeno group. $A^1$ and $A^2$ each independently represent an alkylene group having 1 to 10 carbon atoms, a divalent organic group derived from a bicyclo ring compound, a biphenylene group, or a divalent organic group represented by $-C(T^2)(T^3)-$, or a combination thereof, $T^2$ represents a halogeno group, a carboxy group, a nitro group, a cyano group, a methylenedioxy group, an

acetoxy group, a methylthio group, an alkoxy group having 1 to 9 carbon atoms, an amino group which may be substituted with an alkyl group having 1 to 3 carbon atoms, or an alkyl group having 1 to 10 carbon atoms, which may be substituted with a hydroxy group or a halogeno group, and $T^3$ represents a hydrogen atom or a monovalent group represented by (Formula 2-1-a).

[0058]

[Chem. 19]




(Formula 2-1-a)

In (Formula 2-1-a), * represents a bonding site with a carbon atom to which $T^3$ is bonded. $R^2$ has the same meaning as $R^2$ in (Formula 2-1). a represents an integer of 1 to 6. n3 to n5 each independently represent an integer of 0 to 2. r2 represents an integer of 0 to 3. m1 and m2 each independently represent 0 to 10,000,000.

It is preferable that m1, n3 to n5, and r2 are 0, and m2 is 1.

[0059]

The descriptions of the halogeno group, the alkoxy group, and the alkyl group according to (Formula 2-1) are as described above.

[0060]

Examples of the bicyclo ring compound include dicyclopentadiene, substituted dicyclopentadiene, tetracyclo[4.4.0.12,5.17,10]dodeca-3,8-diene, and substituted tetracyclo[4.4.0.12,5.17,10]dodeca-3,8-diene. Substitution means that one or two or more hydrogen atoms of the bicyclo ring compound are each independently substituted with a halogeno group, a nitro group, an amino group or a hydroxy group, or an alkyl group having 1 to 10 carbon atoms or an aryl group having 6 to 40 carbon atoms, which may be substituted with any of these groups. The divalent organic group derived from the bicyclo ring compound refers to a group having two bonds which is derived by removing any two hydrogen atoms from the bicyclo ring compound.

[0061]

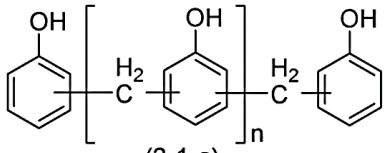
Examples of the aryl group having 6 to 40 carbon atoms include a phenyl group, an o-methylphenyl group, an m-methylphenyl group, a p-methylphenyl group, an o-chlorophenyl group, an m-chlorophenyl group, a p-chlorophenyl group, an o-fluorophenyl group, a p-fluorophenyl group, an o-methoxyphenyl group, a p-

methoxyphenyl group, a p-nitrophenyl group, a p-cyanophenyl group, an α-naphthyl group, a β-naphthyl group, an o-biphenylyl group, an m-biphenylyl group, a p-biphenylyl group, a 1-anthryl group, a 2-anthryl group, a 9-anthryl group, a 1-phenanthryl group, a 2-phenanthryl group, a 3-phenanthryl group, a 4-phenanthryl group, and a 9-phenanthryl group.

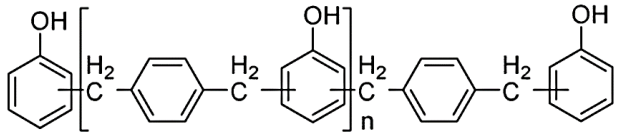
[0062]

Specific examples of the compound represented by (Formula 2-1) include the following compounds.

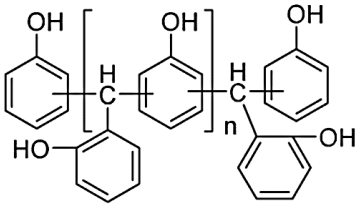
[Chem. 20]



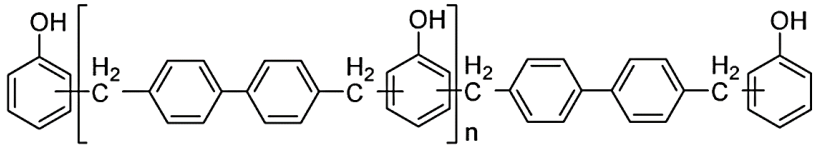
(2-1-a)



(2-1-b)

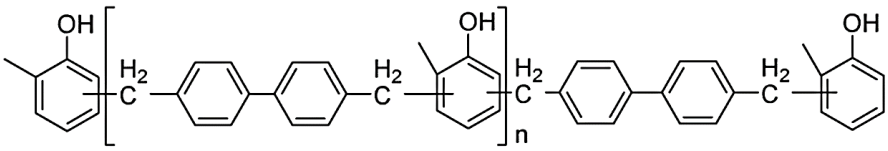


(2-1-d)

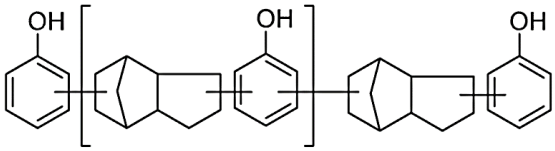


(2-1-c)

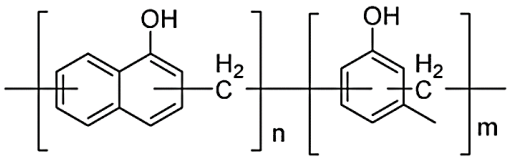
(2-1-e)



(2-1-f)



(2-1-g)

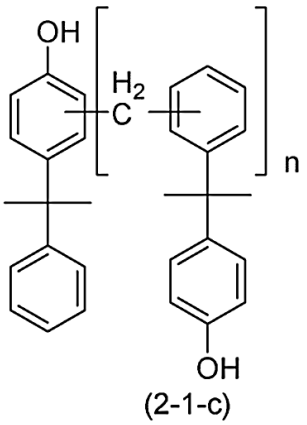


(2-1-h)

The compound or polymer (B) may be a compound shown below.

[0063]

[Chem. 21]




(2-1-c)

$1 \leqq n \leqq 4$

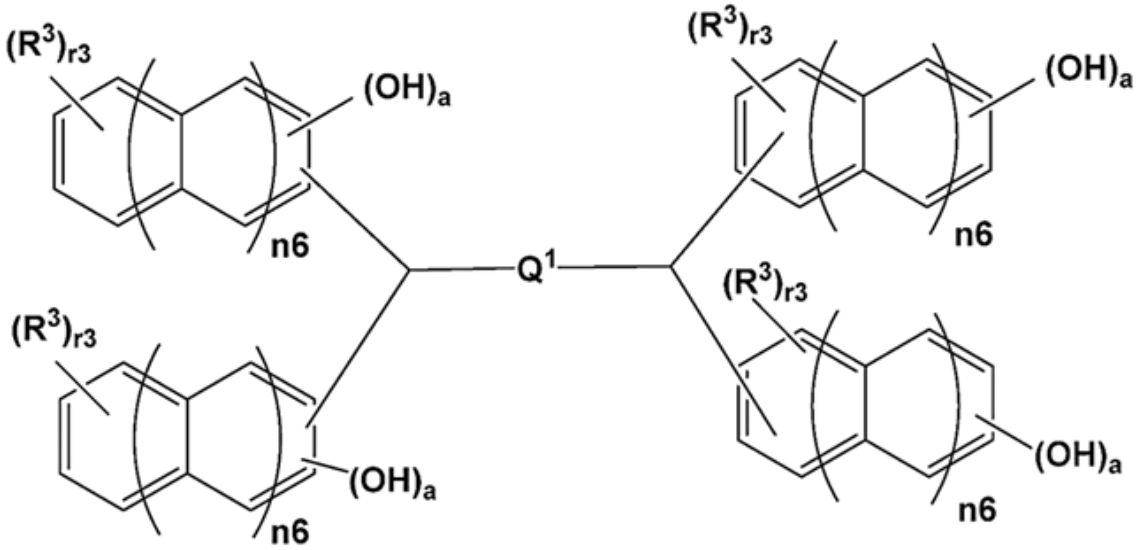
[0064]

<<Aspect 3-2>>

Examples of the compound or polymer (B) used in the present invention include a compound represented by (Formula 2-2).

[0065]

[Chem. 22]




(Formula 2-2)

In the formula, $R^3$ represents a halogeno group, a

carboxy group, a nitro group, a cyano group, a methylenedioxy group, an acetoxy group, a methylthio group, an alkoxy group having 1 to 9 carbon atoms, an amino group which may be substituted with an alkyl group having 1 to 3 carbon atoms, or an alkyl group having 1 to 10 carbon atoms, which may be substituted with a hydroxy group or a halogeno group. $Q^1$ represents a single bond, an oxygen atom, a sulfur atom, a sulfonyl group, a carbonyl group, an imino group, an arylene group having 6 to 40 carbon atoms, or an alkylene group having 1 to 10 carbon atoms, which may be substituted with a halogeno group. a represents an integer of 1 to 6. n6 represents an integer of 0 to 2. r3 represents an integer of 0 to 3.

The descriptions of the alkoxy group, the alkyl group, and the halogeno group of (Formula 2-2) are as described above.

[0066]

Examples of the arylene group having 6 to 40 carbon atoms include a phenylene group, an o-methylphenylene group, an m-methylphenylene group, a p-methylphenylene group, an o-chlorophenylene group, an m-chlorophenylene group, a p-chlorophenylene group, an o-fluorophenylene group, a p-fluorophenylene group, an o-methoxyphenylene group, a p-methoxyphenylene group, a p-nitrophenylene group, a p-cyanophenylene group, an α-naphthylene group, a

β-naphthylene group, an o-biphenylylene group, an m-biphenylylene group, a p-biphenylylene group, a 1-anthrylene group, a 2-anthrylene group, a 9-anthrylene group, a 1-phenanthrylene group, a 2-phenanthrylene group, a 3-phenanthrylene group, a 4-phenanthrylene group, and a 9-phenanthrylene group.

[0067]

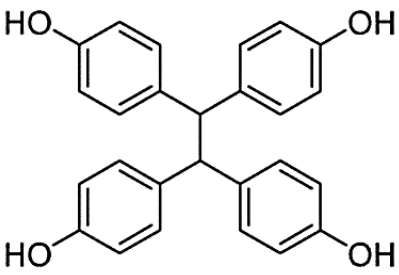
Examples of the alkylene group having 1 to 10 carbon atoms include a methylene group, an ethylene group, an n-propylene group, an isopropylene group, a cyclopropylene group, an n-butylene group, an isobutylene group, an s-butylene group, a t-butylene group, a cyclobutylene group, a 1-methyl-cyclopropylene group, a 2-methyl-cyclopropylene group, an n-pentylene group, a 1-methyl-n-butylene group, a 2-methyl-n-butylene group, a 3-methyl-n-butylene group, a 1,1-dimethyl-n-propylene group, a 1,2-dimethyl-n-propylene group, a 2,2-dimethyl-n-propylene group, a 1-ethyl-n-propylene group, a cyclopentylene group, a 1-methyl-cyclobutylene group, a 2-methyl-cyclobutylene group, a 3-methyl-cyclobutylene group, a 1,2-dimethyl-cyclopropylene group, a 2,3-dimethyl-cyclopropylene group, a 1-ethyl-cyclopropylene group, a 2-ethyl-cyclopropylene group, an n-hexylene group, a 1-methyl-n-pentylene group, a 2-methyl-n-pentylene group, a 3-methyl-n-pentylene group, a 4-methyl-n-pentylene group, a 1,1-dimethyl-n-butylene group, a 1,2-

dimethyl-n-butylene group, a 1,3-dimethyl-n-butylene group, a 2,2-dimethyl-n-butylene group, a 2,3-dimethyl-n-butylene group, a 3,3-dimethyl-n-butylene group, a 1-ethyl-n-butylene group, a 2-ethyl-n-butylene group, a 1,1,2-trimethyl-n-propylene group, a 1,2,2-trimethyl-n-propylene group, a 1-ethyl-1-methyl-n-propylene group, a 1-ethyl-2-methyl-n-propylene group, a cyclohexylene group, a 1-methyl-cyclopentylene group, a 2-methyl-cyclopentylene group, a 3-methyl-cyclopentylene group, a 1-ethyl-cyclobutylene group, a 2-ethyl-cyclobutylene group, a 3-ethyl-cyclobutylene group, a 1,2-dimethyl-cyclobutylene group, a 1,3-dimethyl-cyclobutylene group, a 2,2-dimethyl-cyclobutylene group, a 2,3-dimethyl-cyclobutylene group, a 2,4-dimethyl-cyclobutylene group, a 3,3-dimethyl-cyclobutylene group, a 1-n-propyl-cyclopropylene group, a 2-n-propyl-cyclopropylene group, a 1-isopropyl-cyclopropylene group, a 2-isopropyl-cyclopropylene group, a 1,2,2-trimethyl-cyclopropylene group, a 1,2,3-trimethyl-cyclopropylene group, a 2,2,3-trimethyl-cyclopropylene group, a 1-ethyl-2-methyl-cyclopropylene group, a 2-ethyl-1-methyl-cyclopropylene group, a 2-ethyl-2-methyl-cyclopropylene group, a 2-ethyl-3-methyl-cyclopropylene group, an n-heptylene group, an n-octylene group, an n-nonylene group, and an n-decanylene group.

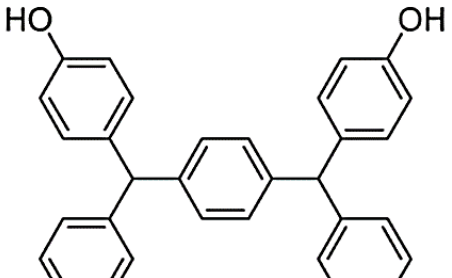
[0068]

Specific examples of the compound represented by (Formula 2-2) include the following compounds.

[Chem. 23]




(2-2-g)

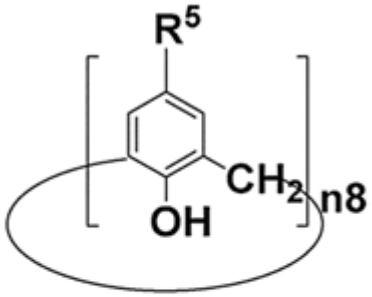



(2-2-h)

The compound (B) may be a compound represented by the following Formula (4-1).

[0069]

[Chem. 24]




Formula (4-1)

In the formula, $R^5$ represents a halogeno group, a carboxy group, a nitro group, a cyano group, a methylenedioxy group, an acetoxy group, a methylthio group, an alkoxy group having 1 to 9 carbon atoms, an amino group

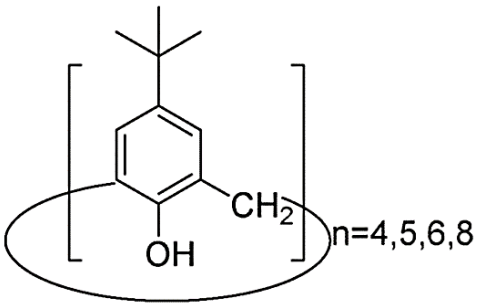
which may be substituted with an alkyl group having 1 to 3 carbon atoms, or an alkyl group having 1 to 10 carbon atoms, which may be substituted with a hydroxy group or a halogeno group. In the formula, n8 represents an integer of 4, 5, 6, or 8.

The descriptions of the terms are as described above.

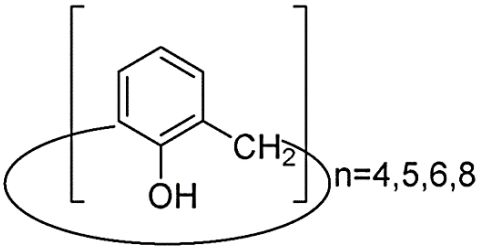
[0070]

Specific examples of the compound represented by Formula (4-1) are shown below.

[Chem. 25]




(2-2-q)

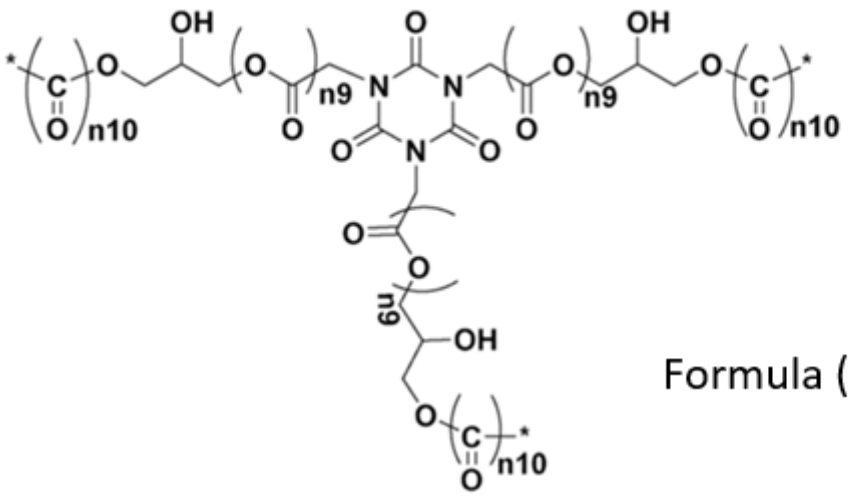



(2-2-r)

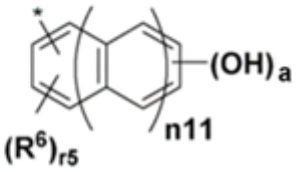
The compound (B) may be compounds represented by the following Formulas (5-1) and (5-1-a).

[0071]

[Chem. 26]



Formula (5-1)



Formula (5-1-a)

In the formula, n9 and n10 each represent an integer of 0 or 1, $R^6$ represents a halogeno group, a carboxy group, a nitro group, a cyano group, a methylenedioxy group, an acetoxy group, a methylthio group, an alkoxy group having 1 to 9 carbon atoms, an amino group which may be substituted with an alkyl group having 1 to 3 carbon atoms, or an alkyl group having 1 to 10 carbon atoms, which may be substituted with a hydroxy group or a halogeno group. a represents an integer of 1 to 6. n11 represents an integer of 1 or 2. r5 represents an integer of 0 to 3. * represents a bonding site between the structure represented by Formula (5-1) and

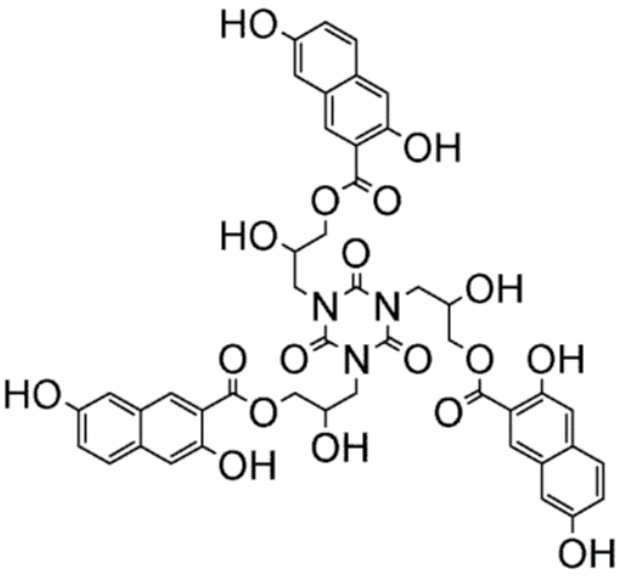
the structure represented by Formula (5-1-a).

The descriptions of the terms are as described above.

[0072]

Specific examples of the compounds represented by Formula (5-1) and Formula (5-1-a) are shown below.

[Chem. 27]

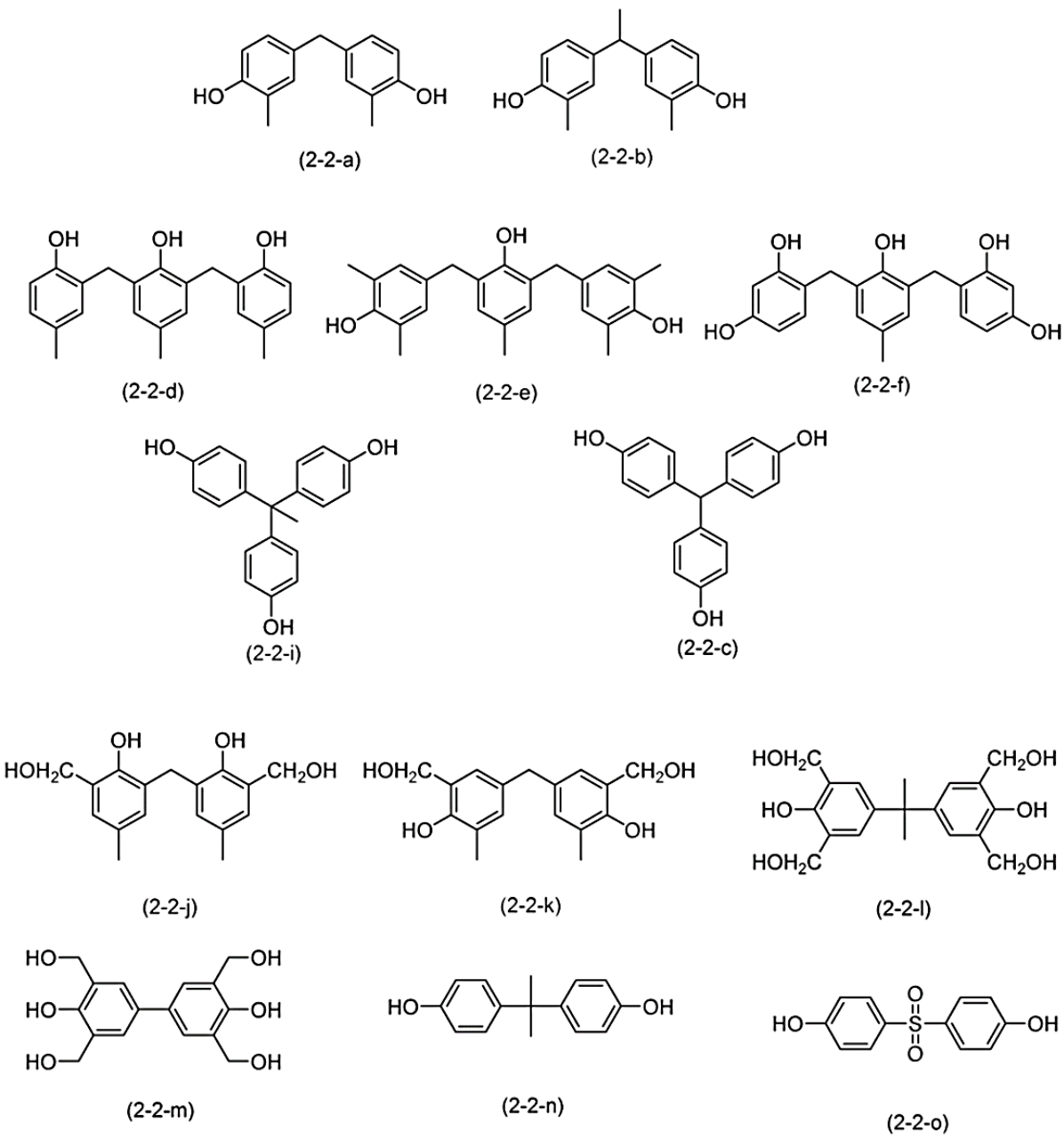


(2-2-t)

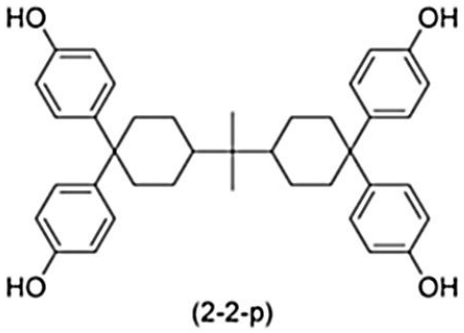
The compound (B) may be a compound shown below.

[0073]

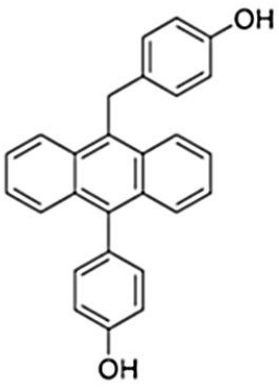
[Chem. 28]




[Chem. 29]




(2-2-p)




(2-2-s)

[0074]

<<Aspect 3-3>>

The compound or polymer (B) used in the present invention is not particularly limited as long as it is a polymer that does not impair the effect of the present invention, and for example, the polymer (B) preferably has at least three or more repeating unit structures.

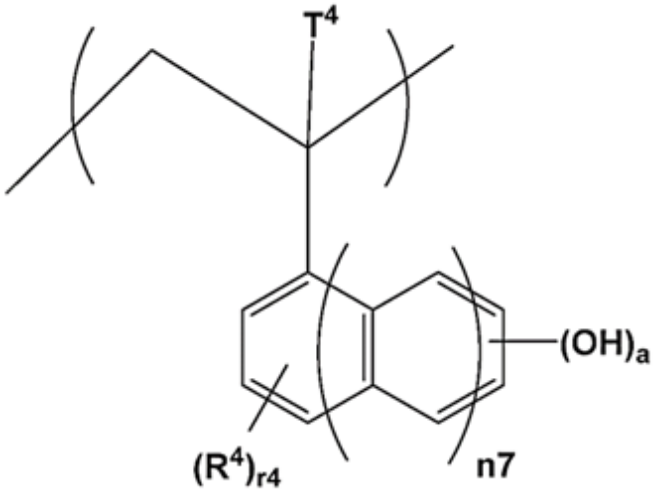
[0075]

A weight-average molecular weight of the polymer (B) is not particularly limited, and is, for example, 1,000 to 50,000.

[0076]

The polymer (B) preferably has a unit structure represented by the following (Formula 3-1).

[Chem. 30]




(Formula 3-1)

in the formula, $T^4$ represents a hydrogen atom or an alkyl group having 1 to 10 carbon atoms, which may be substituted with a halogeno group; $R^4$ represents a halogeno group, a carboxy group, a nitro group, a cyano group, a methylenedioxy group, an acetoxy group, a methylthio group, an alkoxy group having 1 to 9 carbon atoms, an amino group which may be substituted with an alkyl group having 1 to 3 carbon atoms, or an alkyl group having 1 to 10 carbon atoms, which may be substituted with a hydroxy group or a halogeno group; r4 represents an integer of 0 to 3; n7 represents an integer of 0 to 2; and a represents an integer of 1 to 6.

The descriptions of the halogeno group, the alkyl group, and the alkoxy group are as described above.

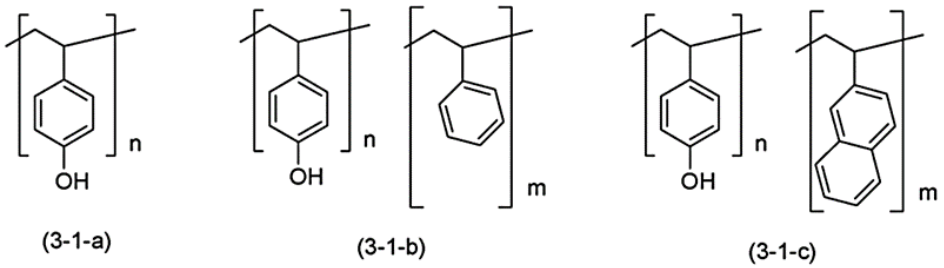
[0077]

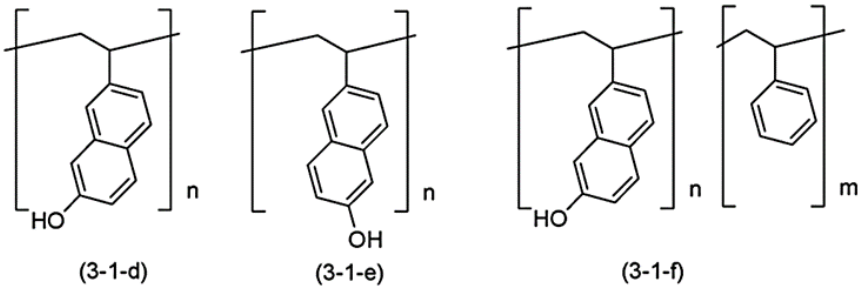
The polymer represented by (Formula 3-1) may be a polymer having one kind of unit structure represented by (Formula 3-1), or a copolymer having two or more kinds of unit structures represented by (Formula 3-1).

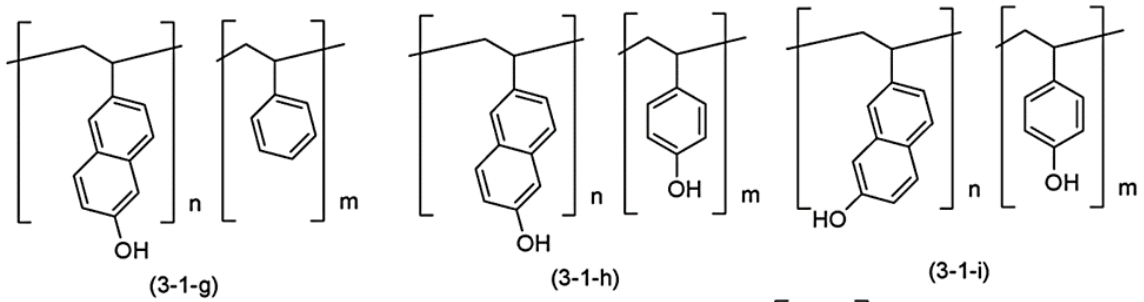
[0078]

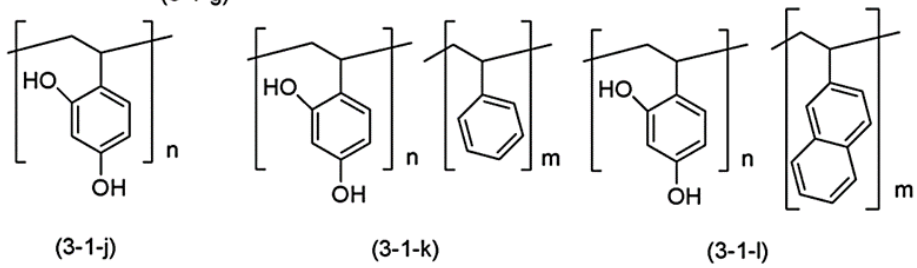
Specific examples of the polymer (B) represented by (Formula 3-1) include polymers having unit structures described below.

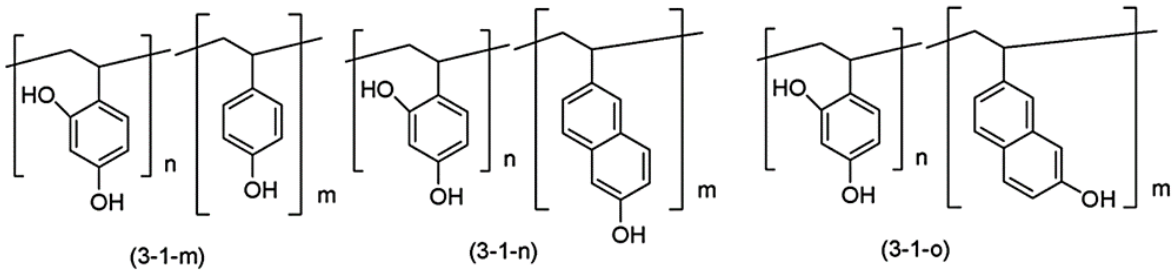
[Chem. 31]




In the above formula, m and n described beside the repeating unit represent a molar ratio of copolymerization.

[0079]

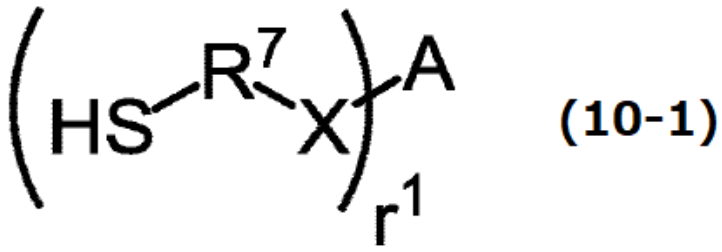
<<Fourth Aspect>>

Examples of the compound (B) used in the present invention include, for example, a compound having a thiol structure.

Examples of the compound having a thiol structure according to the present invention include a polyfunctional thiol compound represented by the following Formula (10-1).

[0080]

[Chem. 32]



(10-1)

in Formula (10-1), $R^7$ represents a single bond or a linear or branched alkylene group having 1 to 6 carbon atoms, X represents a single bond or an ester bond, A represents an organic group having 2 to 12 carbon atoms or a heteroatom, and $r^1$ represents an integer of 2 to 6.

[0081]

A may contain at least one heteroatom, or may not contain any heteroatom.

Examples of the heteroatom in A include an oxygen atom and a nitrogen atom.

[0082]

Examples of the compound having a thiol structure

include 1,2-ethanedithiol, 1,3-propanedithiol, 1,10-decanedithiol, 3,6-dioxaoctane-1,8-dithiol, 2,2'-oxyethanethiol, 2,3-dimercapto-1-propanol, dithioerythritol, dithiothreitol, 1,4-benzenedithiol, 1,3-benzenedithiol, 1,2-benzenedithiol, 4-chloro-1,3-benzenedithiol, 4-methyl-1,2-benzenedithiol, 4,5-dimethyl-1,2-benzenedimethanethiol, 2,3-quinoxalinedithiol, 2-dimethylamino-1,3,5-triazine-4,6-dithiol, 2-methoxy-1,3,5-triazine-4,6-dithiol, 2-dibutylamino-1,3,5-triazine-4,6-dithiol, 2-N-phenylamino-1,3,5-triazine-4,6-dithiol, dicyclohexylamino-1,3,5-triazine-4,6-dithiol, thiocyanuric acid, bismuthiol, bis(2-mercaptoethyl) ether, trimethylolpropane tris(3-mercaptopropionate), tris-[(3-mercaptopropionyloxy)-ethyl]-isocyanurate, tetraethylene glycol bis(3-mercaptopropionate), dipentaerythritol hexakis(3-mercaptopropionate), pentaerythritol tetrakis(3-mercaptobutyrate), 1,4-bis(3-mercaptobutyryloxy)butane, 1,3,5-tris(3-mercaptobutyryloxyethyl)-1,3,5-triazine-2,4,6-(1H,3H,5H)-trione, trimethylolpropane tris(3-mercaptobutyrate), trimethylolethane tris(3-mercaptobutyrate), and pentaerythritol tris(3-mercaptopropyl) ether.

[0083]

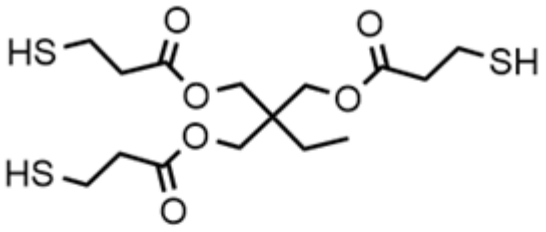
As the polyfunctional thiol compound represented by the above Formula (10-1), commercially available products such

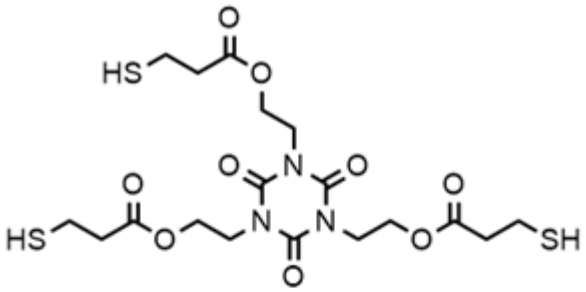
as Karenz MT (registered trademark) PE1, Karenz MT NR1, Karenz MT BD1, TPMB, and TEMB (all manufactured by Showa Denko K.K.), and TMMP, TEMPIC, PEMP, EGMP-4, DPMP, TMMP II-20P, PEMP II-20P, and PEPT (all manufactured by SC Organic Chemical Co., Ltd.) can be used.

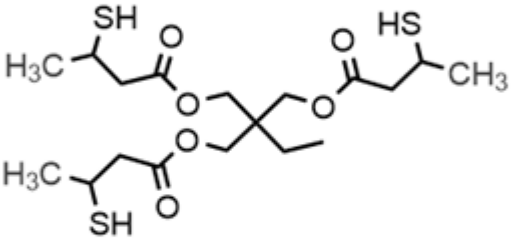
[0084]

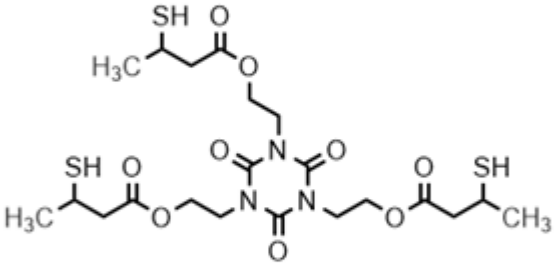
Examples of the polyfunctional thiol compound represented by Formula (10-1) include the following compounds.

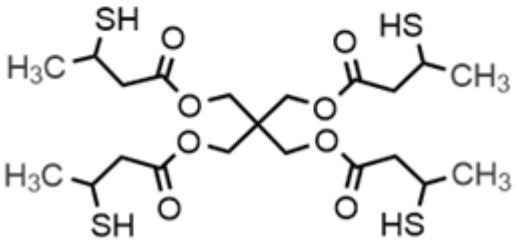
[Chem. 33]











[0085]

Regarding the content of the compound or polymer (B) having a reactive group having reactivity with respect to the reactive group in (A) in the semiconductor element-forming composition of the present invention, for example, the lower limit of the content is usually 1 mass% and preferably 5 mass%, and the upper limit of the content is usually 70 mass%, preferably 50 mass%, and still more preferably 30 mass%, with respect to the total solid

content of the semiconductor element-forming composition.

[0086]

<(C) Basic Curing Agent>

Examples of the basic curing agent (C) used in the present invention include imidazole-based compounds, piperidine compounds, amide-based compounds, amine-based compounds, diazabicycloundecene (DBU)-based compounds, diazabicyclononene (DBN)-based compounds, phosphonium-based compounds, and urea-based compounds. Among these, imidazole-based compounds and diazabicycloundecene (DBU)-based compounds are preferred from the standpoint of storage stability.

[0087]

More preferred embodiments of the basic curing agent (C) include a compound represented by Formula (B1) as shown in a fifth aspect described below, or at least one compound selected from the group consisting of tertiary amine compounds represented by Formula (B2) as shown in a sixth aspect, and the like.

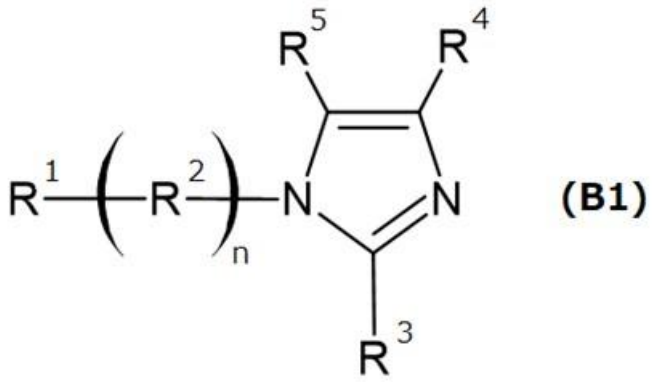
[0088]

<<Fifth Aspect>>

Examples of the basic curing agent (C) in the present invention include an imidazole-based compound represented by the following Formula (B1).

[0089]

[Chem. 34]



(B1)

in Formula (B1), $R^1$ represents a hydrogen atom, an alkyl group having 1 to 4 carbon atoms, an aryl group which may be substituted, a monovalent group obtained by removing, from a triazine ring which may be substituted, a hydrogen atom bonded to a carbon atom of the triazine ring, a cyano group, a hydroxy group, an amino group, a vinyl group, an acryloyloxy group, or a methacryloyloxy group, $R^2$ represents an alkylene group having 1 to 4 carbon atoms, $R^3$ represents a hydrogen atom, an alkyl group having 1 to 17 carbon atoms, or an aryl group which may be substituted, $R^4$ represents a hydrogen atom, a formyl group, an alkyl group having 1 to 4 carbon atoms, which may be substituted, or an alkoxyalkyl group having 4 or less carbon atoms, which may be substituted, $R^5$ represents a hydrogen atom, a formyl group, an alkyl group having 1 to 4 carbon atoms, which may be substituted, or an alkoxyalkyl group having 4 or less carbon atoms, which may be substituted, and n represents 0

or 1.

[0090]

Examples of the substituent in the aryl group which may be substituted or the triazine ring which may be substituted include an amino group and a hydroxy group.

The alkyl group may be either linear or branched.

Examples of the aryl group include a phenyl group, a naphthyl group, a biphenyl group, and an anthryl group.

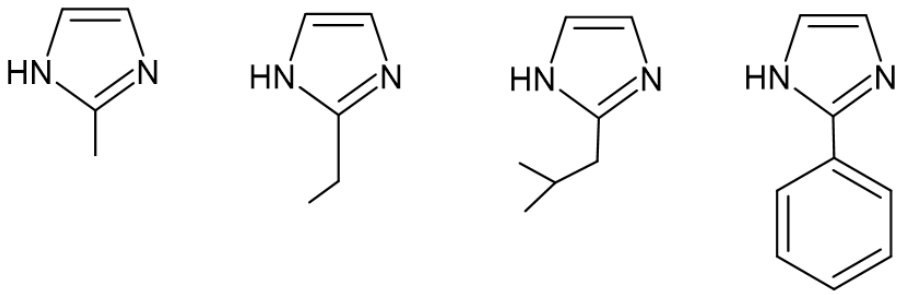
In $R^4$ or $R^5$, examples of the substituents in the alkyl group which may be substituted and the alkoxyalkyl group which may be substituted include a hydroxy group and a cyano group.

[0091]

Specific examples of the imidazole-based compounds used in the present invention are shown below, but the present invention is not limited thereto.

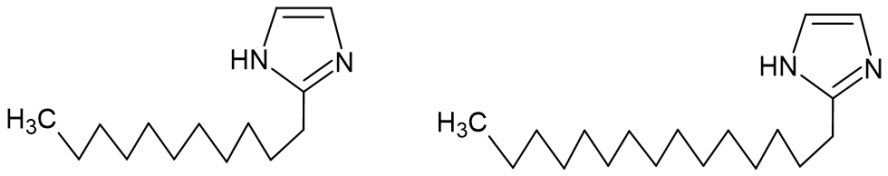
[0092]

[Chem. 35]



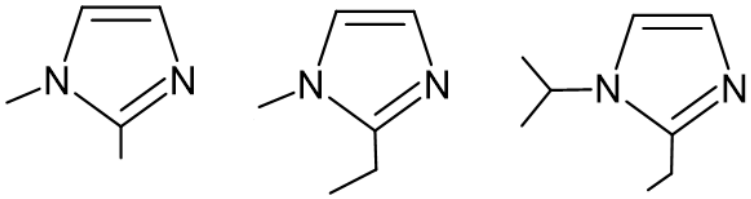
[0093]

[Chem. 36]



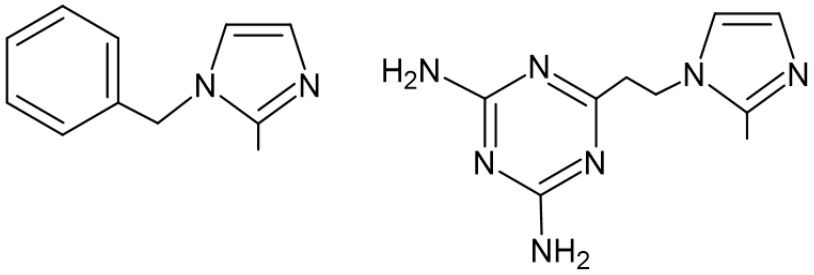
[0094]

[Chem. 37]



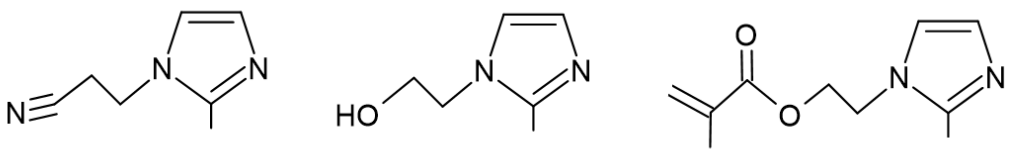
[0095]

[Chem. 38]



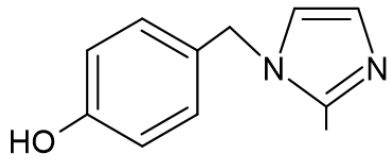
[0096]

[Chem. 39]



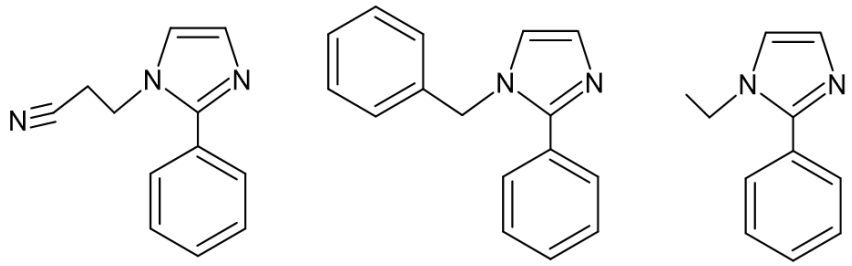
[0097]

[Chem. 40]



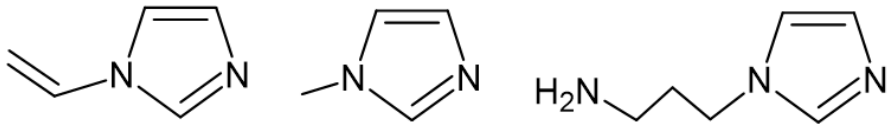
[0098]

[Chem. 41]



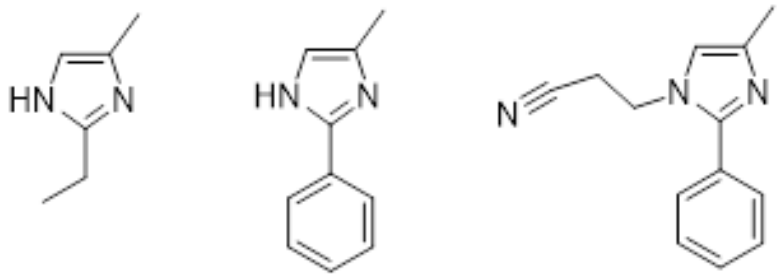
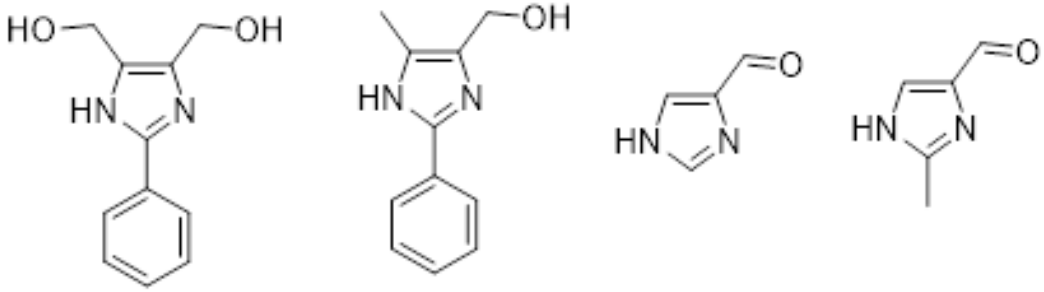
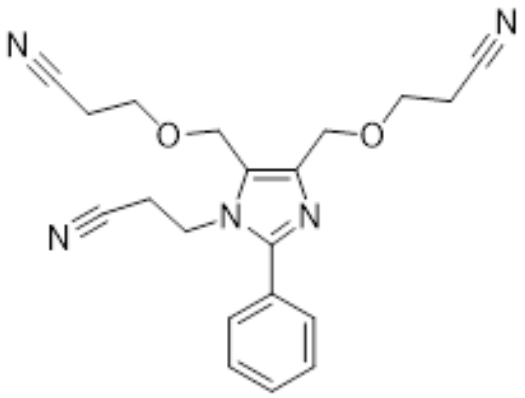
[0099]

[Chem. 42]



[0100]

[Chem. 43]

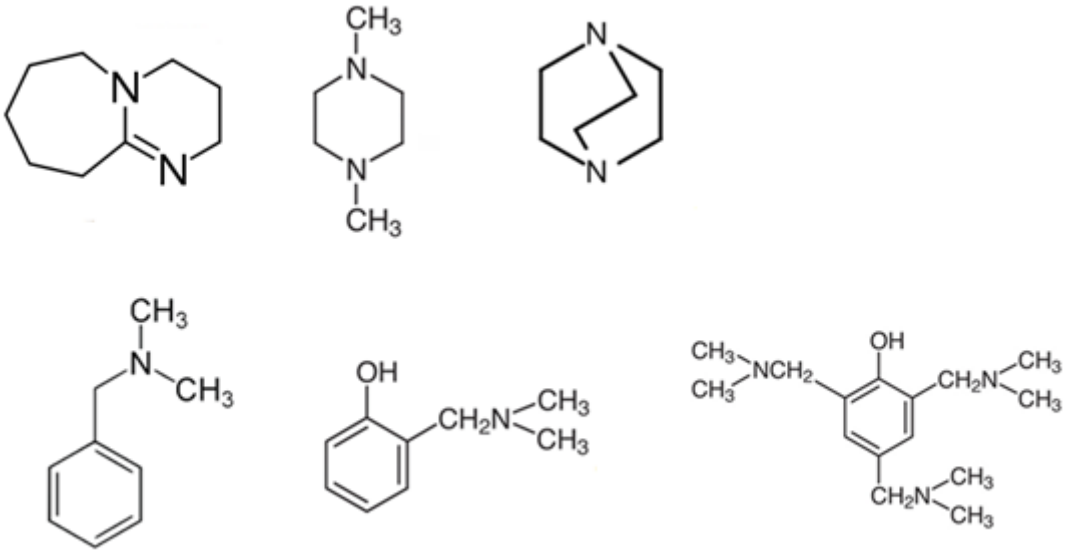
[0101]

<<Sixth Aspect>>

Examples of the basic curing agent (C) referred to in the present invention include at least one compound selected from the group consisting of tertiary amine compounds represented by the following formulae.

[0102]

[Chem. 44]



[0103]

Regarding the content of the basic curing agent (C) in the semiconductor element-forming composition of the present invention, for example, the lower limit of the content is usually 0.0001 mass%, preferably 0.01 mass%, and still more preferably 0.1 mass%, and the upper limit of the content is usually 50 mass%, preferably 40 mass%, and still more preferably 30 mass%, with respect to the total solid content of the semiconductor element-forming composition.

[0104]

<(D) Acidic Additive>

The acidic additive (D) used in the present invention is a compound containing at least one group selected from an imide group, a carboxy group, a sulfonyl group, and a sulfo group.

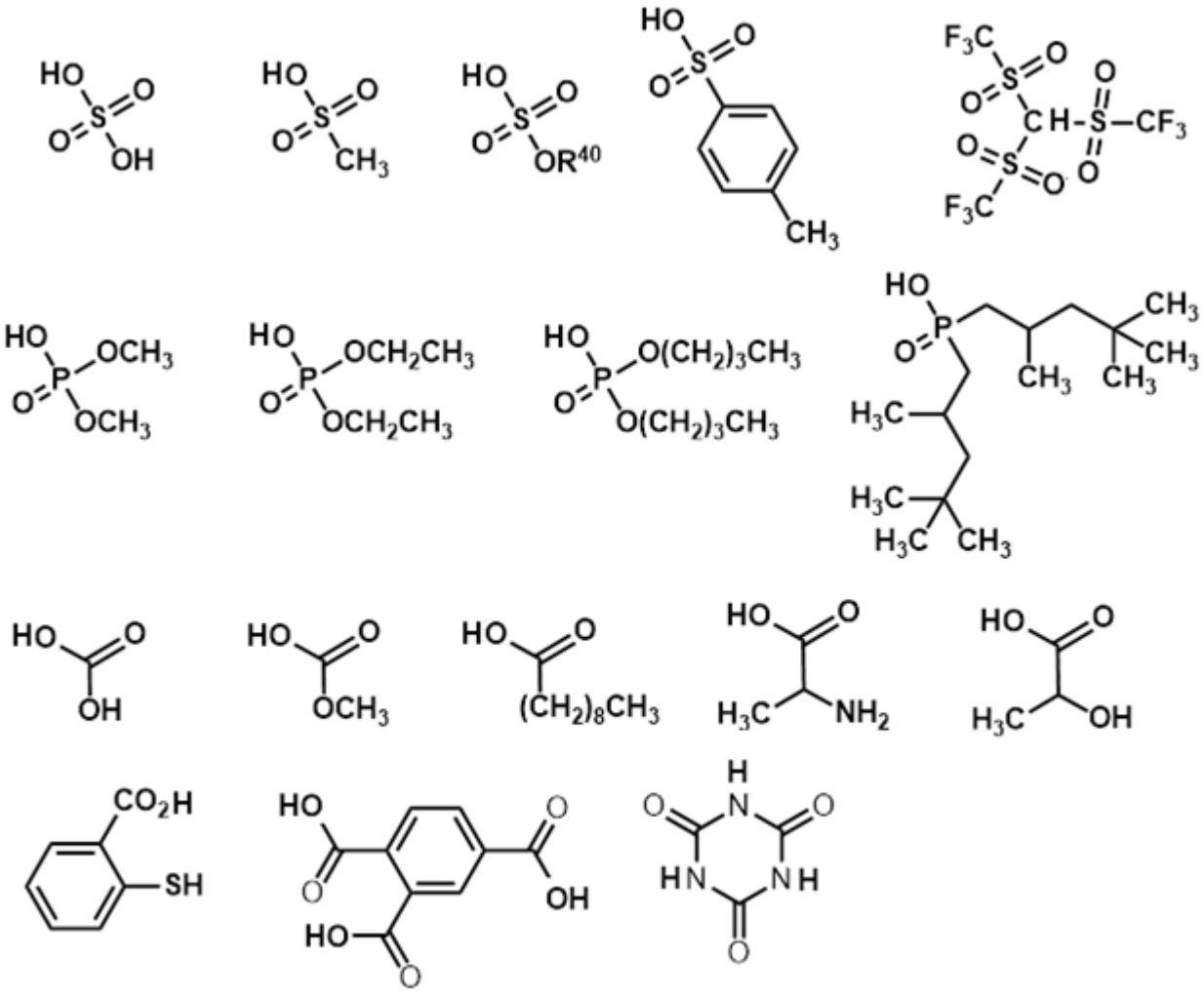
Preferred examples of the acidic additive (D) include acetic acid or maleic acid. An acidic additive having a carboxyl group with an acid dissociation constant (pKa) of 3 or less and high nucleophilicity is not preferred in the present invention from the standpoint of cleaving an epoxy group. A specific example of such an acidic additive is trifluoroacetic acid.

[0105]

Specific examples of the acidic additive used in the present invention are shown below, but the present invention is not limited thereto.

[0106]

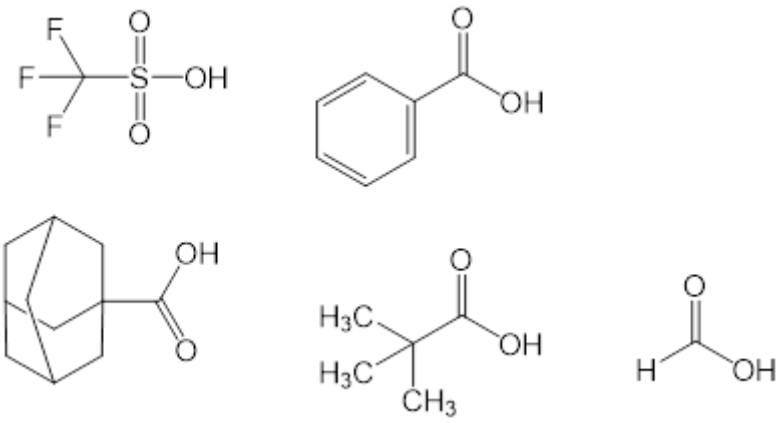
[Chem. 45]



In the formula, $R^{40}$ represents an alkyl group having 1 to 10 carbon atoms.

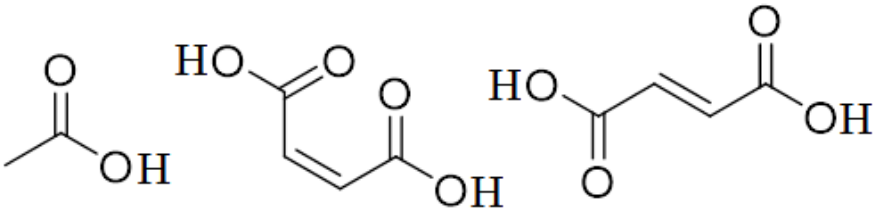
[0107]

[Chem. 46]



[0108]

[Chem. 47]



[0109]

Regarding the content of the acidic additive (D) in the semiconductor element-forming composition of the present invention, for example, the lower limit of the content is usually 0.0001 mass%, preferably 0.01 mass%, and still more preferably 0.1 mass%, and the upper limit of the content is usually 50 mass%, preferably 40 mass%, and still more preferably 30 mass%, with respect to the total solid content of the semiconductor element-forming composition.

[0110]

Regarding the content of the acidic additive (D) with

respect to the basic curing agent (C), for example, it is preferred that the acidic additive (D) is contained in an amount of 0.5 to 1.5 equivalents per 1 equivalent of the basic curing agent (C).

The above equivalents refer to carboxy equivalents that also take into account the number of carboxy groups in a case where the acidic additive has a carboxy group. For example, in a case where acetic acid is used as the acidic additive, the acetic acid is preferably contained at a ratio of 0.5 to 1.5 equivalents (more specifically, for example, 0.8 equivalents) per 1 equivalent of the basic curing agent. In a case where maleic acid is used as the acidic additive, in order to incorporate maleic acid at the same carboxy equivalent as the 0.8 carboxy equivalents indicated in the above case using acetic acid, it is sufficient that maleic acid is contained in an amount of 0.4 equivalents because maleic acid has two carboxy groups. In a case where maleic acid is contained in an amount of 0.4 equivalents, the carboxy equivalent is 0.8 because 0.4 × 2 = 0.8.

[0111]

<(E) Solvent>

The semiconductor element-forming composition of the present invention can be prepared by dissolving the respective components described above in a solvent,

preferably in an organic solvent, and is used in a uniform solution state. Note that, in the present invention, the solvent (E) is different from compounds described in "(Other Components)" described below.

[0112]

As the organic solvent of the semiconductor element-forming composition according to the present invention, any organic solvent capable of dissolving the solid components such as the compounds or polymers of (A) to (D) above and other optional solid components can be used without particular limitation. In particular, since the semiconductor element-forming composition according to the present invention is used in a uniform solution state, it is recommended to use an organic solvent generally used in a lithography process in combination in consideration of coating performance thereof.

[0113]

Examples of the organic solvent include ethylene glycol monomethyl ether, ethylene glycol monoethyl ether, methyl cellosolve acetate, ethyl cellosolve acetate, diethylene glycol monomethyl ether, diethylene glycol monoethyl ether, propylene glycol, propylene glycol monomethyl ether, propylene glycol monoethyl ether, propylene glycol monomethyl ether acetate, propylene glycol propyl ether acetate, toluene, xylene, methyl ethyl ketone, methyl

isobutyl ketone, cyclopentanone, cyclohexanone, cycloheptanone, 4-methyl-2-pentanol, ethyl ethoxyacetate, 2-hydroxyethyl acetate, methyl 3-methoxypropionate, ethyl 3-methoxypropionate, ethyl 3-ethoxypropionate, methyl 3-ethoxypropionate, methyl pyruvate, ethyl pyruvate, ethyl acetate, butyl acetate, isopropyl alcohol, 2-heptanone, methoxycyclopentane, anisole, γ-butyrolactone, N-methylpyrrolidone, N,N-dimethylformamide, and N,N-dimethylacetamide. These solvents can be used alone, or two or more kinds thereof can be used in combination.

[0114]

Among these solvents, propylene glycol monomethyl ether, propylene glycol monomethyl ether acetate, isopropyl alcohol, ethyl acetate, butyl acetate, cyclohexanone, and the like are preferable. In particular, propylene glycol monomethyl ether and propylene glycol monomethyl ether acetate are preferable.

[0115]

The solid content of the semiconductor element-forming composition according to the present invention is usually 0.1 to 70 mass%, and preferably 0.1 to 60 mass%. The solid content is a content ratio of all components excluding the solvent from the semiconductor element-forming composition. The proportion of the compound or polymer (A) in the solid content is preferably 1 to 100 mass%, more preferably 1 to

99.9 mass%, still more preferably 50 to 99.9 mass%, even still more preferably 50 to 95 mass%, and particularly preferably 50 to 90 mass%.

[0116]

<Other Components>

The semiconductor element-forming composition of the present invention may further contain, as (other components), a compound having a hydroxy group and at least one of a hydroxy group and a carbonyl group (hereinafter may be referred to as a "compound represented by (F)" or a "compound (F)").

[0117]

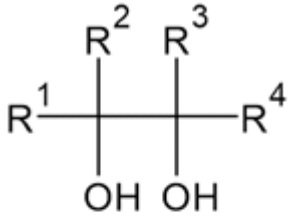
The number of carbon atoms of the compound (F) is, for example, 2 to 20.

[0118]

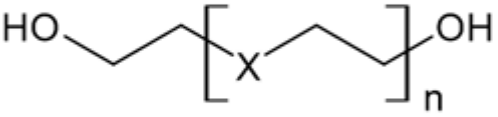
As the compound (F), a compound represented by the following Formula (20-1), a compound represented by the following Formula (20-2), and a compound represented by the following Formula (20-3) are preferable.

[0119]

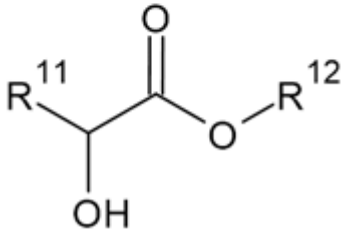
[Chem. 48]




(20-1)




(20-2)




(20-3)

In Formula (20-1), $R^1$ to $R^4$ each independently represent a hydrogen atom, an alkyl group having 1 to 6 carbon atoms, or a hydroxyalkyl group having 1 to 6 carbon atoms.

In Formula (20-2), X represents -O- or -NR- (R represents a hydrogen atom, an alkyl group having 1 to 6 carbon atoms which may have a hydroxy group, an aryl group having 6 to 12 carbon atoms which may have a substituent, or an aralkyl group having 7 to 13 carbon atoms which may have a substituent. n represents an integer of 1 to 3. When n is 2 or 3, X may be the same or different.

In Formula (20-3), $R^{11}$ represents an alkyl group having 1 to 4 carbon atoms. $R^{12}$ represents an alkyl group having 1 to 6 carbon atoms.

[0120]

The alkyl group and the hydroxyalkyl group in $R^1$ to $R^4$ of Formula (20-1) may be linear, branched, or cyclic, and are preferably linear.

It is preferable that, in Formula (20-1), $R^1$ to $R^3$ represent hydrogen atoms, and $R^4$ represents an alkyl group having 1 to 6 carbon atoms or a hydroxyalkyl group having 1 to 6 carbon atoms.

[0121]

Examples of the aromatic ring in the aryl group having 6 to 12 carbon atoms, which may have a substituent, include a benzene ring and a naphthalene ring.

Examples of the aromatic ring in the aralkyl group having 7 to 13 carbon atoms, which may have a substituent, include a benzene ring and a naphthalene ring.

Examples of the substituents in the aryl group having 6 to 12 carbon atoms, which may have a substituent, and the aralkyl group having 7 to 13 carbon atoms, which may have a substituent, include an alkyl group having 1 to 6 carbon atoms and an alkoxy group having 1 to 6 carbon atoms.

[0122]

R in -NR- of Formula (20-2) is preferably an alkyl group having 1 to 6 carbon atoms, which may have a hydroxy group, or an aryl group having 6 to 12 carbon atoms, which may have a substituent. As the alkyl group having 1 to 6 carbon atoms, which may have a hydroxy group, a

hydroxyalkyl group is preferable, and a 2-hydroxyethyl group is more preferable.

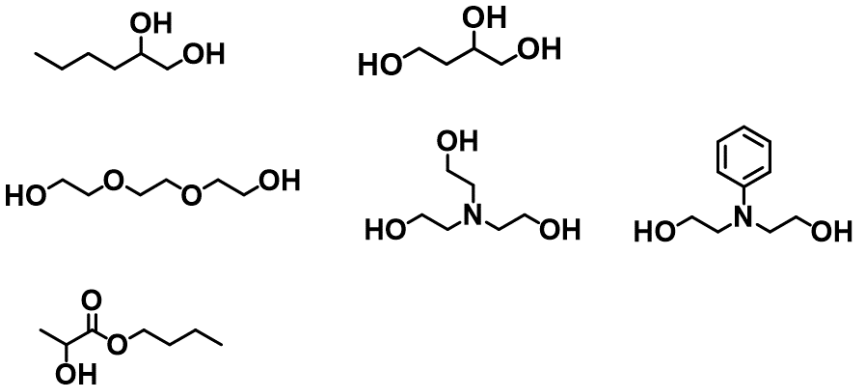
In Formula (20-2), when X is -O-, n is preferably 2.

In Formula (20-2), when X is -NR-, n is preferably 1.

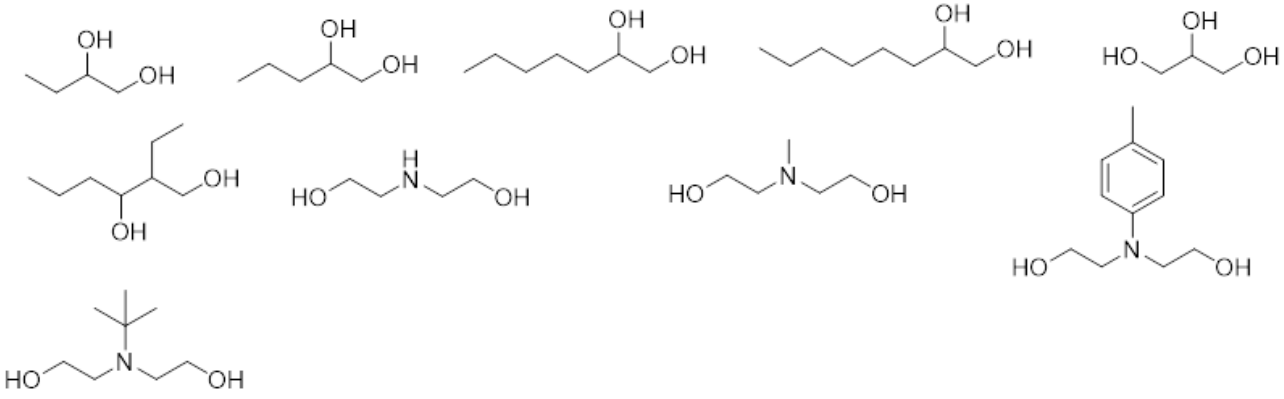
[0123]

Examples of the compound (F) include the following compounds.

[Chem. 49]



[Chem. 50]



[0124]

The content of the compound (F) in the semiconductor element-forming composition of the present invention is not

particularly limited, but the lower limit of the content thereof is preferably 0.5 mass%, more preferably 1 mass%, and particularly preferably 5 mass%, with respect to the compound or polymer (A), and an upper limit of the content thereof is preferably 50 mass%, more preferably 30 mass%, and particularly preferably 20 mass%, with respect to the compound or polymer (A).

[0125]

The content of the compound (F) in the semiconductor element-forming composition of the present invention is not particularly limited, but the lower limit of the content is preferably 0.0001 mass%, more preferably 0.005 mass%, and particularly preferably 0.001 mass%, and the upper limit of the content is preferably 50 mass%, more preferably 30 mass%, and particularly preferably 20 mass%, with respect to the solvent (E).

[0126]

(Specific Methods of Using Semiconductor Element-Forming Composition, Semiconductor Element-Forming Film, and the like)

The semiconductor element-forming composition of the present invention can be used in various forms, for example, as a resist underlayer film-forming composition in a lithography process (particularly, a resist underlayer film-forming composition having an antireflection

function), a protective film-forming composition for forming a protective film having excellent resistance to a wet etching solution for semiconductor use, or a cavity-forming composition for forming a cavity between conductive wiring patterns.

[0127]

<Mode of Use as Resist Underlayer Film-Forming Composition or Protective Film-Forming Composition>

Hereinafter, a method for manufacturing a resist-patterned substrate and a method for manufacturing a semiconductor device using the semiconductor element-forming composition (resist underlayer film-forming composition) according to the present invention will be described.

[0128]

The semiconductor element-forming film of the present invention is a baked product of a coating film composed of the semiconductor element-forming composition of the present invention.

The method for manufacturing a substrate with a semiconductor element-forming film according to the present invention includes a step of applying the semiconductor element-forming composition of the present invention onto a semiconductor substrate and baking the composition to form a semiconductor element-forming film. The method for

manufacturing a substrate with a semiconductor element-forming film is used in the manufacture of semiconductors.

The method for manufacturing a resist-patterned substrate according to the present invention includes a step of applying the semiconductor element-forming composition of the present invention or the resist underlayer film-forming composition according to the present invention onto a semiconductor substrate and baking the composition to form a semiconductor element-forming film as a resist underlayer film, and a step of forming a resist film on the semiconductor element-forming film, and then exposing and developing the resist film to form a resist pattern. The method for manufacturing a resist-patterned substrate is used for manufacturing a semiconductor.

An embodiment of the method for manufacturing a semiconductor device according to the present invention includes a step of forming a semiconductor element-forming film on a semiconductor substrate on which an inorganic film may be formed on a surface using the semiconductor element-forming composition of the present invention, forming a resist pattern on the semiconductor element-forming film, dry-etching the semiconductor element-forming film using the resist pattern as a mask to expose the surface of the inorganic film or the semiconductor

substrate, and wet-etching and cleaning the inorganic film or the semiconductor substrate using a wet etching solution for semiconductor use with the semiconductor element-forming film after dry etching as a mask.

An embodiment of the method for manufacturing a semiconductor device of the present invention includes a step of forming a resist underlayer film using the resist underlayer film-forming composition of the present invention on a semiconductor substrate having a surface on which an inorganic film is optionally formed, forming a resist pattern on the resist underlayer film, dry etching the resist underlayer film using the resist pattern as a mask to expose the inorganic film or the surface of the semiconductor substrate, and etching the inorganic film or the semiconductor substrate using the resist underlayer film after dry etching as a mask.

[0129]

A resist-patterned substrate according to the present invention can be produced by applying the above-described semiconductor element-forming composition (resist underlayer film-forming composition) onto a semiconductor substrate and baking the composition.

[0130]

Examples of the semiconductor substrate onto which the semiconductor element-forming composition (resist

underlayer film-forming composition) of the present invention is applied include a silicon wafer, a germanium wafer, and a compound semiconductor wafer such as a gallium arsenide wafer, an indium phosphide wafer, a gallium nitride wafer, an indium nitride wafer, or an aluminum nitride wafer.

[0131]

In the case of using the semiconductor substrate having a surface on which an inorganic film is formed, the inorganic film is formed by, for example, an atomic layer deposition (ALD) method, a chemical vapor deposition (CVD) method, a reactive sputtering method, an ion plating method, a vacuum deposition method, or a spin coating method (spin-on-glass, SOG). Examples of the inorganic film include a polysilicon film, a silicon oxide film, a silicon nitride film, a silicon oxynitride film, a boro-phospho silicate glass (BPSG) film, a titanium nitride film, a titanium oxynitride film, a tungsten nitride film, a gallium nitride film, and a gallium arsenide film. The semiconductor substrate may be a stepped substrate in which so-called vias (holes), trenches (grooves), and the like are formed. For example, a via has a substantially circular shape when viewed from the top, the diameter of the substantially circular shape is, for example, 2 nm to 20 nm, and the depth is 50 nm to 500 nm, and a trench has,

for example, a width of a groove (a recess in the substrate) of 2 nm to 20 nm, and a depth of 50 nm to 500 nm. Since the weight-average molecular weight and average particle size of the compound contained in the semiconductor element-forming composition (resist underlayer film-forming composition) of the present invention are small, the composition can be embedded even in a stepped substrate as described above without defects such as voids. It is an important characteristic that there are no defects such as voids for the next step (wet etching and dry etching of semiconductor substrate, the formation of a resist pattern) of semiconductor manufacturing.

[0132]

The semiconductor element-forming composition (the resist underlayer film-forming composition) of the present invention is applied onto the semiconductor substrate by an appropriate coating method such as a spinner or a coater. Thereafter, the semiconductor element-forming film (also referred to as a resist underlayer film or a protective film) is formed by baking using a heating means such as a hot plate. The baking conditions are appropriately selected from a baking temperature of 100°C to 400°C and a baking time of 0.3 minutes to 60 minutes. Preferably, the baking temperature is 120°C to 350°C and the baking time is

0.5 minutes to 30 minutes. More preferably, the baking temperature is 150°C to 300°C and the baking time is 0.8 minutes to 10 minutes. The film thickness of the formed semiconductor element-forming film is, for example, 0.001 μm to 10 μm, preferably 0.002 μm to 1 μm, and more preferably 0.005 μm to 0.5 μm. In a case where the temperature during the baking is lower than the above range, crosslinking is insufficient, and it may be difficult to obtain resistance of the formed semiconductor element-forming film to a resist solvent or a basic hydrogen peroxide aqueous solution. On the other hand, when the temperature at the time of baking is higher than the range, the semiconductor element-forming film may be decomposed by heat.

[0133]

A resist film is formed on the semiconductor element-forming film formed as described above, and then exposed and developed to form a resist pattern.

The exposure is performed through a mask (reticle) for forming a predetermined pattern, and for example, i-line, KrF excimer laser, ArF excimer laser, extreme ultraviolet light (EUV), or an electron beam (EB) is used. An alkaline developer is used for development, and a development temperature is appropriately selected from 5°C to 50°C, and a development time is appropriately selected from 10

seconds to 300 seconds. As the alkaline developer, for example, it is possible to use alkaline aqueous solutions such as aqueous solutions of inorganic alkalis such as sodium hydroxide, potassium hydroxide, sodium carbonate, sodium silicate, sodium metasilicate, and ammonia solutions, primary amines such as ethylamine and n-propylamine, secondary amines such as diethylamine and di-n-butylamine, tertiary amines such as triethylamine and methyldiethylamine, alcoholamines such as dimethylethanolamine and triethanolamine, quaternary ammonium salts such as tetramethylammonium hydroxide, tetraethylammonium hydroxide, and choline, cyclic amines such as pyrrole and piperidine, and other alkaline aqueous solutions. Further, an alcohol such as isopropyl alcohol, or a surfactant such as a nonionic surfactant can be added in an appropriate amount to the aqueous solution of an alkali and used. Among these, as the developers, it is preferable to use quaternary ammonium salts, and still more preferable to use tetramethylammonium hydroxide and choline. Furthermore, surfactants or other additives can be added to these developers. It is also possible to use a method in which development is performed with an organic solvent such as butyl acetate in place of the alkaline developer and a portion where the alkali dissolution rate of the photoresist is not improved is developed.

[0134]

Next, the semiconductor element-forming film (also referred to as a resist underlayer film or a protective film) is dry-etched using the formed resist pattern as a mask. In this case, in a case where the inorganic film is formed on the surface of the semiconductor substrate used, the surface of the inorganic film is exposed, and in a case where the inorganic film is not formed on the surface of the used semiconductor substrate, the surface of the semiconductor substrate is exposed.

[0135]

Furthermore, a desired pattern is formed by wet etching using a wet etching solution for semiconductor use with the semiconductor element-forming film after dry etching (and the resist pattern remaining on the semiconductor element-forming film/resist underlayer film, in a case where the resist pattern remains thereon) as a mask.

[0136]

As the wet etching solution for semiconductor use, a general chemical liquid for etching a semiconductor wafer can be used, and for example, both an acidic substance and a basic substance can be used.

[0137]

Examples of the substance exhibiting acidity include hydrogen peroxide, hydrofluoric acid, ammonium fluoride,

acidic ammonium fluoride, ammonium hydrogen fluoride, buffered hydrofluoric acid, hydrochloric acid, nitric acid, sulfuric acid, phosphoric acid, and a mixed solution thereof.

[0138]

Examples of the substance exhibiting basicity include basic hydrogen peroxide water obtained by mixing ammonia, sodium hydroxide, potassium hydroxide, sodium cyanide, potassium cyanide, or an organic amine such as triethanolamine with hydrogen peroxide water to make the pH basic. Specific examples thereof include SC-1 (ammonia-hydrogen peroxide solution). In addition, a substance capable of adjusting a pH to a basic pH, for example, a substance capable of finally adjusting a pH to a basic pH by mixing urea with hydrogen peroxide water and causing thermal decomposition of urea by heating to generate ammonia, can be used as a chemical liquid for wet etching.

[0139]

Among these, acidic hydrogen peroxide water or basic hydrogen peroxide water is preferable.

[0140]

These chemical liquids may contain an additive such as a surfactant.

[0141]

The temperature during use of the wet etching solution

for semiconductor use is desirably 25°C to 90°C, and still more desirably 40°C to 80°C. The wet etching time is desirably 0.5 minutes to 30 minutes, and still more desirably 1 minute to 20 minutes.

[0142]

<Mode of Use as Cavity-Forming Composition>

Hereinafter, a method for manufacturing a semiconductor element or a semiconductor device using the semiconductor element-forming composition according to the present invention as a cavity-forming composition will be described.

[0143]

The cavity-forming composition is suitably used for manufacturing a semiconductor element, including the following steps (A) to (D).

Step (A): a step of applying the cavity-forming composition onto a semiconductor substrate on which conductive wiring patterns are formed

Step (B): a step of heating the semiconductor substrate after the step (A) to form a cavity-forming film formed of the cavity-forming composition between the conductive wiring patterns

Step (C): a step of forming an insulating layer on the conductive wiring patterns and the cavity-forming film between the conductive wiring patterns after the step (B)

Step (D): a step of heating the semiconductor substrate to burn out the cavity-forming film after the step (C)

[0144]

Hereinafter, steps (A) to (D) will be described.

<Step (A)>

The step (A) is a step of applying the cavity-forming composition according to the present invention onto a semiconductor substrate on which conductive wiring patterns are formed.

[0145]

Examples of the semiconductor substrate include a silicon wafer, a germanium wafer, and a compound semiconductor wafer such as gallium arsenide, indium phosphide, gallium nitride, indium nitride, or aluminum nitride.

[0146]

The material, size, and shape of the conductive wiring pattern are not particularly limited.

Examples of the material of the conductive wiring pattern include copper, cobalt, ruthenium, molybdenum, chromium, tungsten, manganese, rhodium, nickel, palladium, platinum, silver, gold, and aluminum.

[0147]

An insulating layer may be formed on the conductive wiring pattern.

Examples of the material of the insulating layer include silicon dioxide, silicon oxycarbide, silicon oxynitride, silicon nitride, silicon carbon nitride (SiCN), aluminum nitride, aluminum oxynitride, and aluminum oxide.

Examples of a method for forming the insulating layer include vapor deposition.

[0148]

The line width of each wiring line of the conductive wiring pattern is not particularly limited, but is, for example, 3 nm to 50 nm.

The width of a space between the wiring lines of the conductive wiring pattern is not particularly limited, but is, for example, 3 nm to 50 nm.

[0149]

A method for forming the conductive wiring pattern is not particularly limited, and for example, a conventionally known lithography process can be used.

[0150]

The cavity-forming composition is applied onto, for example, a semiconductor substrate by an appropriate application method such as a spinner or a coater.

[0151]

<Step (B)>

The step (B) is a step of heating the semiconductor substrate after the step (A) to form a cavity-forming film

formed of the cavity-forming composition between the conductive wiring patterns.

[0152]

The semiconductor substrate is heated using, for example, a heating means such as a hot plate.

Since the cavity-forming composition contains a component for crosslinking the polymer, a crosslinked structure of the polymer is formed by heating the semiconductor substrate in step (B). As a result, a cavity-forming film formed of the cavity-forming composition containing a crosslinked polymer is obtained.

The heating temperature here can be appropriately selected depending on the type of the polymer and the type of the crosslinking component contained in the cavity-forming composition, and the like, but is preferably 200°C to 260°C.

The heating time is not particularly limited, but is preferably 30 seconds to 2 minutes.

[0153]

<Step (C)>

The step (C) is a step of forming an insulating layer on the conductive wiring patterns and the cavity-forming film between the conductive wiring patterns after the step (B).

[0154]

The material of the insulating layer is not particularly limited, and may be an organic material or an inorganic material. When the insulating layer is formed of an inorganic material, examples of the material include silicon dioxide, silicon oxycarbide, silicon oxynitride, silicon nitride, silicon carbon nitride (SiCN), aluminum nitride, aluminum oxynitride, aluminum oxide, tantalum oxide, titanium oxide, yttrium oxide, lanthanum oxide, hafnium oxide, zirconium oxide, and mixtures thereof.

[0155]

The thickness of the insulating layer is not particularly limited, but is, for example, 0.2 nm to 10 nm.

[0156]

A method for forming the insulating layer is not particularly limited, but a chemical vapor deposition method (CVD method) is preferable.

That is, in the step (C), the insulating layer is preferably formed by chemical vapor deposition.

[0157]

<Step (D)>

The step (D) is a step of heating the semiconductor substrate to burn out the cavity-forming film after the step (C).

[0158]

In a case where the cavity-forming film is heated, the

cavity-forming film is thermally decomposed and burned out due to thermal decomposition of the polymer.

[0159]

The heating temperature here is not particularly limited as long as it is a temperature at which the cavity-forming film disappears, and can be appropriately selected according to the type of the polymer and the like, but is preferably 300°C to 500°C.

The heating time is not particularly limited, but is preferably 30 to 90 minutes.

[0160]

A burnout amount (decomposition ratio) of the cavity-forming film is desirably 100%, but does not have to be 100%, and may be 99.9% or less. The decomposition ratio is preferably 90% or more, more preferably 95% or more, more preferably 96% or more, more preferably 97% or more, still more preferably 98% or more, and particularly preferably 99% or more.

Examples

[0161]

Hereinafter, the contents and effects of the present invention will be described in more detail by way of examples, but the present invention is not limited thereto.

[0162]

The weight-average molecular weight of the compound synthesized in the following Examples of the present specification is a measurement result by gel permeation chromatography (hereinafter, abbreviated as GPC). In the measurement, a GPC apparatus manufactured by Tosoh Corporation was used, and measurement conditions and the like are as follows:

[0163]

GPC column

Column temperature: 40°C

Solvent: tetrahydrofuran (THF)

Flow rate: 0.35 ml/min

Standard sample: Polystyrene (manufactured by Tosoh Corporation)

[0164]

<Descriptions of terms>

PGME: Propylene glycol monomethyl ether

PGMEA: propylene glycol monomethyl ether acetate

[0165]

<Example 1>

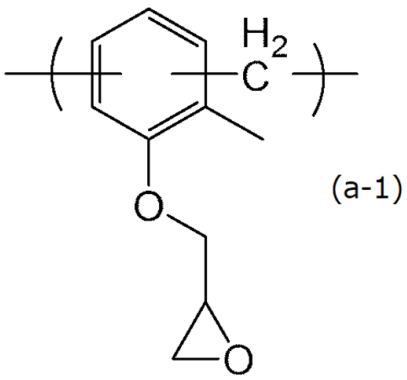
A mixture of 0.49 g of epoxy novolac resin EOCN-104S (a product of Nippon Kayaku Co., Ltd., corresponding to the following Formula (a-1), weight-average molecular weight: 3,100), 0.97 g of 3,7-dihydroxy-2-naphthoic acid-tri(2,3-epoxypropyl) isocyanurate copolymer (corresponding to the

following Formula (2-2-t)), 0.032 g of 1B2PZ (a product of Shikoku Chemicals Corporation, corresponding to the following Formula (c-1)), 0.007 g of acetic acid (a product of Kanto Chemical Co., Inc.), 68.95 g of PGMEA, and 29.55 g of PGME was prepared to give a solution with a solid content of 1.5 mass%. The solution was filtered using a polytetrafluoroethylene microfilter having a pore size of 0.2 μm to prepare a semiconductor element-forming composition (resist underlayer film-forming composition).

In Example 1, acetic acid is contained in an amount of 0.007/60.05 equivalents relative to 0.032/234.3 equivalents of 1B2PZ. This means that acetic acid is contained in an amount of 0.85 equivalents per 1 equivalent of 1B2PZ.

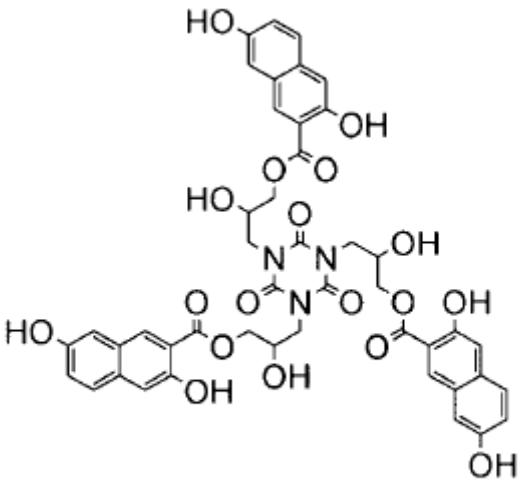
[0166]

[Chem. 51]



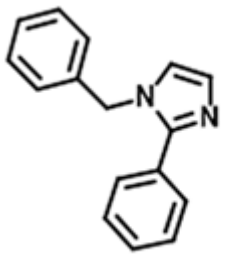

(a-1)

[Chem. 52]



(2-2-t)

[Chem. 53]



(c-1)

[0167]

<Example 2>

A mixture of 0.49 g of epoxy novolac resin EOCN-104S (a product of Nippon Kayaku Co., Ltd., corresponding to the above Formula (a-1), weight-average molecular weight: 3,100), 0.97 g of 3,7-dihydroxy-2-naphthoic acid-tri(2,3-epoxypropyl) isocyanurate copolymer (corresponding to the above Formula (2-2-t)), 0.031 g of 1B2PZ (a product of Shikoku Chemicals Corporation, corresponding to the above Formula (c-1)), 0.008 g of maleic acid (a product of Tokyo

Chemical Industry Co., Ltd.), 68.95 g of PGMEA, and 29.55 g of PGME was prepared to give a solution with a solid content of 1.5 mass%. The solution was filtered using a polytetrafluoroethylene microfilter having a pore size of 0.2 μm to prepare a semiconductor element-forming composition (resist underlayer film-forming composition).

[0168]

<Example 3>

A mixture of 0.48 g of epoxy novolac resin EOCN-104S (a product of Nippon Kayaku Co., Ltd., corresponding to the above Formula (a-1), weight-average molecular weight: 3,100), 0.97 g of 3,7-dihydroxy-2-naphthoic acid-tri(2,3-epoxypropyl) isocyanurate copolymer (corresponding to the above Formula (2-2-t)), 0.032 g of 1B2PZ (a product of Shikoku Chemicals Corporation, corresponding to the above Formula (c-1)), 0.016 g of trifluoromethanesulfonic acid (a product of Tokyo Chemical Industry Co., Ltd.), 68.95 g of PGMEA, and 29.55 g of PGME was prepared to give a solution with a solid content of 1.5 mass%. The solution was filtered using a polytetrafluoroethylene microfilter having a pore size of 0.2 μm to prepare a semiconductor element-forming composition (resist underlayer film-forming composition).

[0169]

<Comparative Example 1>

A mixture of 0.48 g of epoxy novolac resin EOCN-104S (a product of Nippon Kayaku Co., Ltd., corresponding to the above Formula (a-1), weight-average molecular weight: 3,100), 0.97 g of 3,7-dihydroxy-2-naphthoic acid-tri(2,3-epoxypropyl) isocyanurate copolymer (corresponding to the above Formula (2-2-t)), 0.032 g of 1B2PZ (a product of Shikoku Chemicals Corporation, corresponding to the above Formula (c-1)), 0.013 g of trifluoroacetic acid (a product of Tokyo Chemical Industry Co., Ltd.), 68.95 g of PGMEA, and 29.55 g of PGME was prepared to give a solution with a solid content of 1.5 mass%. The solution was filtered using a polytetrafluoroethylene microfilter having a pore size of 0.2 μm to prepare a semiconductor element-forming composition (resist underlayer film-forming composition).

[0170]

<Comparative Example 2>

A mixture of 0.49 g of epoxy novolac resin EOCN-104S (a product of Nippon Kayaku Co., Ltd., corresponding to the above Formula (a-1), weight-average molecular weight: 3,100), 0.97 g of 3,7-dihydroxy-2-naphthoic acid-tri(2,3-epoxypropyl) isocyanurate copolymer (corresponding to the above Formula (2-2-t)), 0.040 g of 1B2PZ (a product of Shikoku Chemicals Corporation, corresponding to the above Formula (c-1)), 68.95 g of PGMEA, and 29.55 g of PGME was prepared to give a solution with a solid content of 1.5

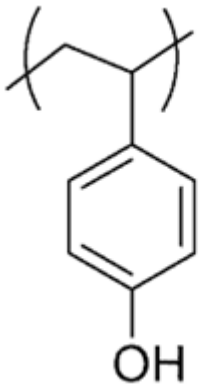
mass%. The solution was filtered using a polytetrafluoroethylene microfilter having a pore size of 0.2 μm to prepare a semiconductor element-forming composition (resist underlayer film-forming composition).

[0171]

<Example 4>

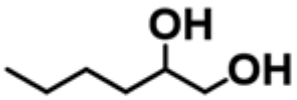
A mixture of 2.88 g of epoxy novolac resin EOCN-104S (a product of Nippon Kayaku Co., Ltd., corresponding to the above Formula (a-1), weight-average molecular weight: 3,100), 0.72 g of VP-2500 (a product of Nippon Soda Co., Ltd., corresponding to the following Formula (b-1), weight-average molecular weight: 3,687), 0.036 g of 1B2PZ (a product of Shikoku Chemicals Corporation, corresponding to the above Formula (c-1)), 0.007 g of acetic acid (a product of Kanto Chemical Co., Inc.), 0.29 g of 1,2-hexanediol (a product of Tokyo Chemical Industry Co., Ltd., corresponding to the following Formula (f-1)), 0.58 g of Karenz MT [registered trademark] TPMB (a product of Resonac Corporation, corresponding to the following Formula (b-3)), 28.65 g of PGMEA, and 66.85 g of PGME was prepared to give a solution with a solid content of 4.0 mass%. The solution was filtered using a polytetrafluoroethylene microfilter having a pore size of 0.2 μm to prepare a semiconductor element-forming composition (protective film-forming composition).

[Chem. 54]



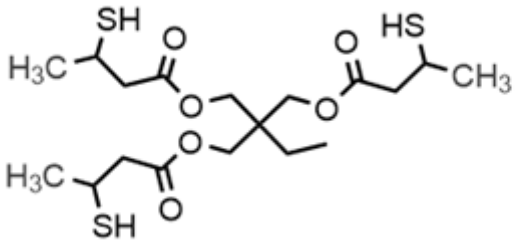

(b-1)

[Chem. 55]




(f-1)

[Chem. 56]




(b-3)

[0172]

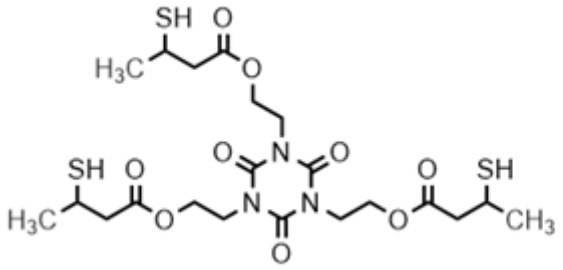
<Example 5>

A mixture of 2.88 g of epoxy novolac resin EOCN-104S (a product of Nippon Kayaku Co., Ltd., corresponding to the above Formula (a-1), weight-average molecular weight: 3,100), 0.72 g of VP-2500 (a product of Nippon Soda Co., Ltd., corresponding to the above Formula (b-1), weight-

average molecular weight: 3,687), 0.036 g of 1B2PZ (a product of Shikoku Chemicals Corporation, corresponding to the above Formula (c-1)), 0.007 g of acetic acid (a product of Kanto Chemical Co., Inc.), 0.29 g of 1,2-hexanediol (a product of Tokyo Chemical Industry Co., Ltd., corresponding to the following Formula (f-1)), 0.58 g of Karenz MT [registered trademark] NR1 (a product of Resonac Corporation, corresponding to the following Formula (b-4)), 28.65 g of PGMEA, and 66.85 g of PGME was prepared to give a solution with a solid content of 4.0 mass%. The solution was filtered using a polytetrafluoroethylene microfilter having a pore size of 0.2 μm to prepare a semiconductor element-forming composition (protective film-forming composition).

[0173]

[Chem. 57]



(b-4)

[0174]

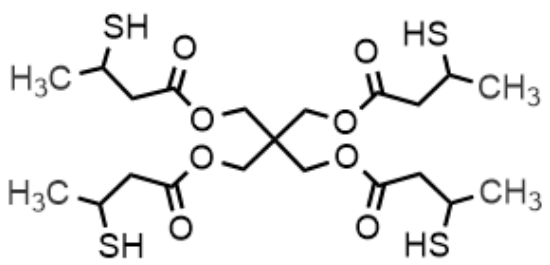
<Example 6>

A mixture of 2.88 g of epoxy novolac resin EOCN-104S (a product of Nippon Kayaku Co., Ltd., corresponding to the

above Formula (a-1), weight-average molecular weight: 3,100), 0.72 g of VP-2500 (a product of Nippon Soda Co., Ltd., corresponding to the above Formula (b-1), weight-average molecular weight: 3,687), 0.036 g of 1B2PZ (a product of Shikoku Chemicals Corporation, corresponding to the above Formula (c-1)), 0.007 g of acetic acid (a product of Kanto Chemical Co., Inc.), 0.29 g of 1,2-hexanediol (a product of Tokyo Chemical Industry Co., Ltd., corresponding to the following Formula (f-1)), 0.58 g of Karenz MT [registered trademark] PE1 (a product of Resonac Corporation, corresponding to the following Formula (b-5)), 28.65 g of PGMEA, and 66.85 g of PGME was prepared to give a solution with a solid content of 4.0 mass%. The solution was filtered using a polytetrafluoroethylene microfilter having a pore size of 0.2 μm to prepare a semiconductor element-forming composition (protective film-forming composition).

[0175]

[Chem. 58]




(b-5)

[0176]

<Comparative Example 3>

A mixture of 2.88 g of epoxy novolac resin EOCN-104S (a product of Nippon Kayaku Co., Ltd., corresponding to the above Formula (a-1), weight-average molecular weight: 3,100), 0.72 g of VP-2500 (a product of Nippon Soda Co., Ltd., corresponding to the above Formula (b-1), weight-average molecular weight: 3,687), 0.043 g of 1B2PZ (a product of Shikoku Chemicals Corporation, corresponding to the above Formula (c-1)), 0.29 g of 1,2-hexanediol (a product of Tokyo Chemical Industry Co., Ltd., corresponding to the following Formula (f-1)), 0.58 g of Karenz MT [registered trademark] TPMB (a product of Resonac Corporation, corresponding to the above Formula (b-3)), 28.65 g of PGMEA, and 66.85 g of PGME was prepared to give a solution with a solid content of 4.0 mass%. The solution was filtered using a polytetrafluoroethylene microfilter having a pore size of 0.2 μm to prepare a semiconductor element-forming composition (protective film-forming composition).

[0177]

<Comparative Example 4>

A mixture of 2.88 g of epoxy novolac resin EOCN-104S (a product of Nippon Kayaku Co., Ltd., corresponding to the above Formula (a-1), weight-average molecular weight: 3,100), 0.72 g of VP-2500 (a product of Nippon Soda Co.,

Ltd., corresponding to the above Formula (b-1), weight-average molecular weight: 3,687), 0.043 g of 1B2PZ (a product of Shikoku Chemicals Corporation, corresponding to the above Formula (c-1)), 0.29 g of 1,2-hexanediol (a product of Tokyo Chemical Industry Co., Ltd., corresponding to the following Formula (f-1)), 0.58 g of Karenz MT [registered trademark] NR1 (a product of Resonac Corporation, corresponding to the following Formula (b-4)), 28.65 g of PGMEA, and 66.85 g of PGME was prepared to give a solution with a solid content of 4.0 mass%. The solution was filtered using a polytetrafluoroethylene microfilter having a pore size of 0.2 μm to prepare a semiconductor element-forming composition (protective film-forming composition).

[0178]

<Comparative Example 5>

A mixture of 2.88 g of epoxy novolac resin EOCN-104S (a product of Nippon Kayaku Co., Ltd., corresponding to the above Formula (a-1), weight-average molecular weight: 3,100), 0.72 g of VP-2500 (a product of Nippon Soda Co., Ltd., corresponding to the above Formula (b-1), weight-average molecular weight: 3,687), 0.043 g of 1B2PZ (a product of Shikoku Chemicals Corporation, corresponding to the above Formula (c-1)), 0.29 g of 1,2-hexanediol (a product of Tokyo Chemical Industry Co., Ltd., corresponding

to the following Formula (f-1)), 0.58 g of Karenz MT [registered trademark] PE1 (a product of Resonac Corporation, corresponding to the following Formula (b-5)), 28.65 g of PGMEA, and 66.85 g of PGME was prepared to give a solution with a solid content of 4.0 mass%. The solution was filtered using a polytetrafluoroethylene microfilter having a pore size of 0.2 μm to prepare a semiconductor element-forming composition (protective film-forming composition).

[0179]

(Test of Performance as Antireflection Film)

The resist underlayer film-forming compositions prepared in Examples 1 and 2 and Comparative Example 1 were applied onto a silicon wafer using a spinner. The coated substrate was then baked on a hot plate at 220°C for 1 minute to form a resist underlayer film (film thickness: 400 nm). A commercially available photoresist solution (manufactured by JSR Corporation, trade name: AR2772) was applied onto the resist underlayer film using a spinner, and baked on a hot plate at 110°C for 90 seconds to form a photoresist film (film thickness: 0.2 μm).

Next, exposure was performed through a photomask set so that the line width of the photoresist and the width between the lines of the photoresist after development were 65 nm using a scanner manufactured by Nikon Corporation,

NSRS307E (wavelength: 193 nm, NA: 0.85, σ: 0.62/0.93 (ANNULAR)). Thereafter, post-exposure baking (PEB) was performed on a hot plate at 110°C for 90 seconds, and after cooling, development was performed using a 0.26 N tetramethylammonium hydroxide aqueous solution as a developer in an industry-standard 60-second single-paddle process to obtain a photoresist pattern.

The lithography performance of the obtained photoresist pattern was evaluated by observing a cross-section perpendicular to the substrate, that is, the silicon wafer, using a scanning electron microscope (SEM).

As a result, it was observed that the cross-sectional shapes of all the photoresist patterns produced using the antireflection films of Examples 1 and 2 and Comparative Example 1 had a good straight foot profile and were substantially rectangular.

[0180]

(Chemical Resistance Test)

In the chemical resistance test, a silicon wafer on which a titanium nitride film (thickness: 50 nm) was formed was cut into 3 cm square pieces. Next, an evaluation material was applied by spin coating and baked at 220°C for 60 seconds to form a chemical solution protective film.

[0181]

(Resistance Test against Basic Hydrogen Peroxide

Aqueous Solution)

Each of the protective film-forming compositions prepared in Examples 1 to 6 and the protective film-forming composition prepared in Comparative Examples 1 to 3 was applied to the silicon substrate having the surface on which the titanium nitride film was formed, and baked at 220°C to produce a coating film, and the coating film was immersed in a basic hydrogen peroxide aqueous solution having the composition as shown in Table 1 at the temperature shown in the same table for 1 minute 30 seconds, washed with water, and dried, and the state of the coating film was then visually observed. The film thickness of the applied chemical resistance protective film and the results of the resistance test are shown in Table 2 below. "×" indicates a state in which the film peeled off, while "○" indicates a state in which the film did not peel off.

[0182]

[Table 1]

| 28 mass% aqueous ammonia solution | 33 mass% aqueous hydrogen peroxide solution | Ultrapure water | Temperature |
|---|---|---|---|
| 10 mL | 40 mL | 200 mL | 50°C |

[0183]

[Table 2]

| | Film thickness (nm) | Resistance Test |
|---|---|---|

| | | against Basic Hydrogen Peroxide Aqueous Solution |
|---|---|---|
| Example 1 | 40 | ○ |
| Example 2 | 40 | ○ |
| Example 3 | 40 | ○ |
| Example 4 | 100 | ○ |
| Example 5 | 100 | ○ |
| Example 6 | 100 | ○ |
| Comparative Example 1 | 40 | ○ |
| Comparative Example 2 | 40 | ○ |
| Comparative Example 3 | 100 | ○ |
| Comparative Example 4 | 100 | ○ |
| Comparative Example 5 | 100 | ○ |

[0184]

(Storage Stability Test)

The storage stability test was conducted by measuring the molecular weight distribution by gel permeation chromatography (hereinafter abbreviated as GPC) and the epoxy value of samples stored for 3 days at each of -20°C and 60°C.

These are the measurement results obtained by GPC analysis. As described above, the GPC measurement was performed using a GPC instrument manufactured by Tosoh Corporation under the measurement conditions described below.

GPC column

Column temperature: 40°C

Solvent: tetrahydrofuran (THF)

Flow rate: 0.35 ml/min

Standard sample: Polystyrene (manufactured by Tosoh Corporation)

[0185]

In the GPC measurement, samples in which no overall shift was observed in a case where the molecular weight distributions of the samples stored at -20°C and 60°C were superimposed were evaluated as "o", and those in which a partial shift was observed were evaluated as "×".

The evaluation results for each of Examples 1 to 5 and Comparative Examples 1 to 3 are shown in Table 3 below.

[0186]

[Table 3]

| | Storage stability |
|---|---|
| Example 1 | o |
| Example 2 | o |
| Example 3 | o |
| Example 4 | o |
| Example 5 | o |
| Example 6 | o |
| Comparative Example 1 | × |
| Comparative Example 2 | × |
| Comparative Example 3 | × |
| Comparative Example 4 | × |
| Comparative Example 5 | × |

Industrial Applicability

[0187]

As shown in the above results, the results of the storage stability test by GPC in Comparative Examples were poor, whereas the results in Examples were good.

The semiconductor element-forming composition according to the present invention exhibits good coatability and film-curability in a short period of time, while also showing good results in terms of storage stability.

CLAIMS

[claim 1] A semiconductor element-forming composition comprising:

(A) a compound or polymer having a reactive group represented by a cyclic ether structure represented by the following Formula (I);

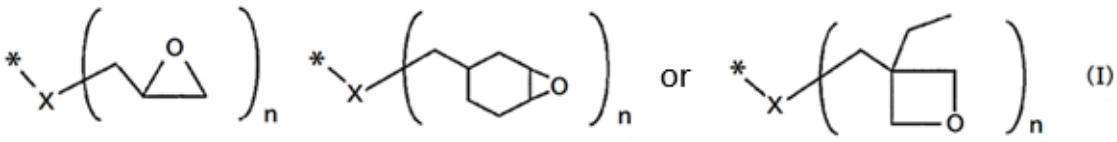
(B) a compound or polymer having a reactive group having reactivity with respect to the reactive group in (A);

(C) a basic curing agent;

(D) an acidic additive; and

(E) a solvent,

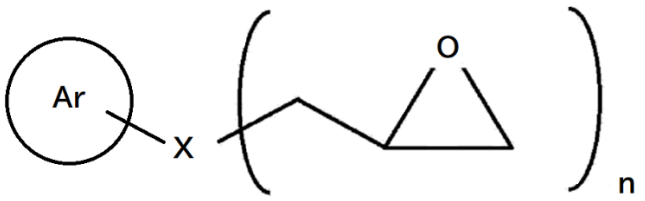
[Chem. 1]




wherein * indicates a bonding site; n represents 1 or 2; when n = 1, X represents an ether bond, an ester bond, or an amide bond; and when n = 2, X represents a nitrogen atom or an amide bond.

[claim 2] The semiconductor element-forming composition according to claim 1, wherein the compound in (A) is a compound having a partial structure represented by the following Formula (III),

[Chem. 2]

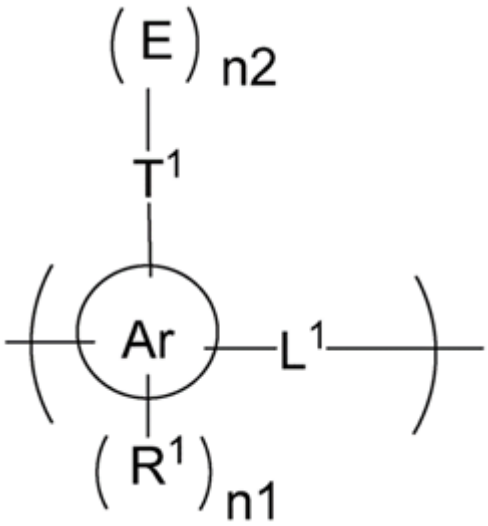



(III)

wherein Ar represents a benzene ring, a naphthalene ring, or an anthracene ring; n is 1 or 2; and when n = 1, X represents an ether bond, an ester bond, or an amide bond, and when n = 2, X represents a nitrogen atom or an amide bond.

[claim 3] The semiconductor element-forming composition according to claim 1, wherein the polymer in (A) is a polymer having a novolac structure having a unit structure represented by the following Formula (1-1),

[Chem. 3]




Formula (1-1)

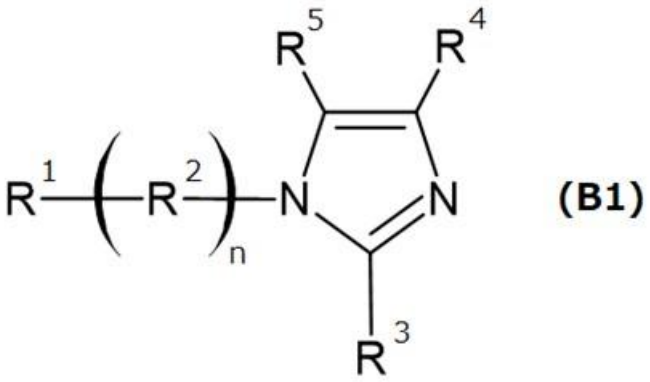
wherein Ar represents a benzene ring, a naphthalene ring, or an anthracene ring; $R^1$ represents a hydroxy group,

a mercapto group which may be protected by a methyl group, an amino group which may be protected by a methyl group, a halogeno group, or an alkyl group having 1 to 10 carbon atoms, which may be substituted with or interrupted by a heteroatom and may be substituted with a hydroxy group; n1 represents an integer of 0 to 3; $L^1$ represents a single bond or an alkylene group having 1 to 10 carbon atoms; n2 represents 1 or 2; E represents a group having an epoxy group or a group having an oxetanyl group; when n2 = 1, $T^1$ represents an alkylene group having 1 to 10 carbon atoms, which may be interrupted by an ether bond, an ester bond, or an amide bond; and when n2 = 2, $T^1$ represents a trivalent hydrocarbon group having 1 to 10 carbon atoms, which may be interrupted by a nitrogen atom or an amide bond.

[claim 4] The semiconductor element-forming composition according to claim 1, wherein the compound or polymer in (B) is a compound or polymer having a phenolic hydroxy group, or a compound having a thiol structure.

[claim 5] The semiconductor element-forming composition according to claim 1, wherein the basic curing agent in (C) is a compound represented by the following Formula (B1),

[Chem. 4]

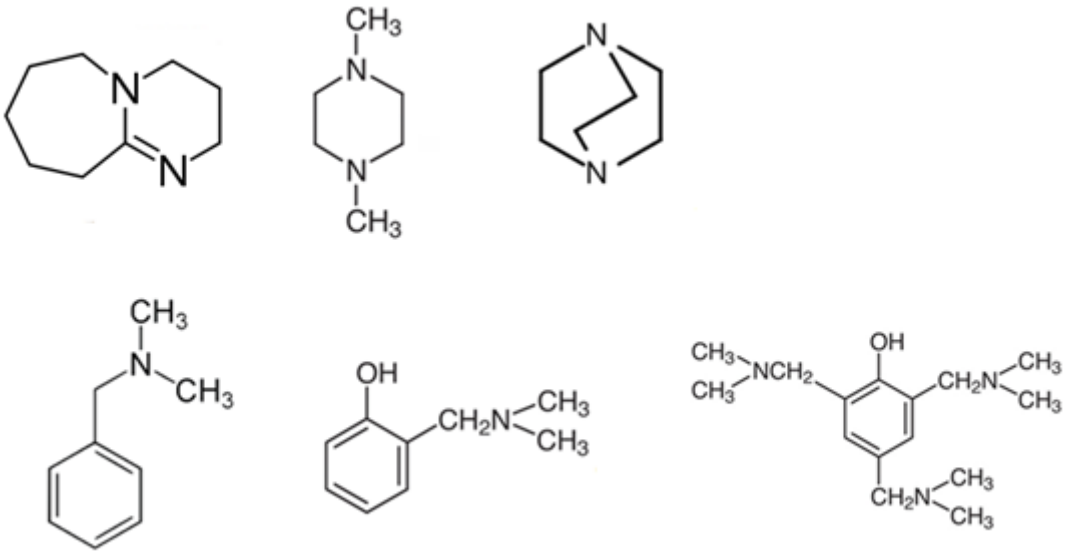


(B1)

wherein $R^1$ represents a hydrogen atom, an alkyl group having 1 to 4 carbon atoms, an aryl group which may be substituted, a monovalent group obtained by removing, from a triazine ring which may be substituted, a hydrogen atom bonded to a carbon atom of the triazine ring, a cyano group, a hydroxy group, an amino group, a vinyl group, an acryloyloxy group, or a methacryloyloxy group; $R^2$ represents an alkylene group having 1 to 4 carbon atoms; $R^3$ represents a hydrogen atom, an alkyl group having 1 to 17 carbon atoms, or an aryl group which may be substituted; $R^4$ represents a hydrogen atom, a formyl group, an alkyl group having 1 to 4 carbon atoms, which may be substituted, or an alkoxyalkyl group having 4 or less carbon atoms, which may be substituted; $R^5$ represents a hydrogen atom, a formyl group, an alkyl group having 1 to 4 carbon atoms, which may be substituted, or an alkoxyalkyl group having 4 or less carbon atoms, which may be substituted; and n represents 0 or 1.

[claim 6] The semiconductor element-forming composition according to claim 1, wherein the basic curing agent in (C) is at least one compound selected from the group consisting of tertiary amine compounds represented by the following formulae,

[Chem. 5]



.

[claim 7] The semiconductor element-forming composition according to claim 1, wherein the acidic additive in (D) is a compound containing at least one group selected from an imide group, a carboxy group, a sulfonyl group, and a sulfo group.

[claim 8] The semiconductor element-forming composition according to claim 7, wherein the acidic additive in (D) is acetic acid or maleic acid.

[claim 9] The semiconductor element-forming composition according to claim 1, wherein the solvent in (E) includes at least one solvent selected from the group consisting of propylene glycol monomethyl ether, propylene glycol, monomethyl ether acetate, isopropyl alcohol, ethyl acetate, butyl acetate, and cyclohexanone.

[claim 10] The semiconductor element-forming composition according to claim 1, wherein the semiconductor element-forming composition is used as a cavity-forming composition for forming a cavity between conductive wiring patterns.

[claim 11] The semiconductor element-forming composition according to claim 1, wherein the semiconductor element-forming composition is used as a protective film-forming composition for forming a protective film having excellent resistance to a wet etching solution for semiconductor use.

[claim 12] The semiconductor element-forming composition according to claim 1, wherein the semiconductor element-forming composition is used as a resist underlayer film-forming composition in a lithography process.

[claim 13] A semiconductor element-forming film that is a baked product of a coating film composed of the semiconductor element-forming composition according to any one of claims 1 to 12.