

## [DESCRIPTION]

## [Title of Invention]

RESIST COMPOSITION AND METHOD FOR PRODUCING RESIST FILM  
USING THE SAME

5

## [Technical Field]

## [0001]

The present invention relates to a resist composition to be used for producing a semiconductor element, a semiconductor integrated circuit, or the like, and a method for producing a resist film using the resist composition.

10

## [Background Art]

## [0002]

In the process of producing devices such as semiconductors, microfabrication by a lithography technique with the use of a resist has been commonly performed. The process of microfabrication includes forming a thin resist layer on a semiconductor substrate such as a silicon wafer, covering the layer with a mask pattern corresponding to a pattern of a target device, exposing the layer with an active ray such as an ultraviolet ray through the mask pattern, developing the exposed layer to obtain a resist pattern, and etching the substrate with the obtained resist pattern as a protective film, thereby forming fine irregularities corresponding to the pattern described above.

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## [0003]

A photosensitive photoresist composition is proposed, which is obtained by mixing a polymer with another component (for example, a photoinitiator, a crosslinking agent, or the like) in PGMEA as a spin coating solvent (PTL 1).

25

## [Citation List]

## [Patent Literature]

30

## [0004]

[PTL 1] Japanese Translation of PCT Application No. 2021-518584

## [Summary of Invention]

[Technical Problem]

[0005]

The inventor has considered that there are still one or more problems for which improvements are still required regarding the resist composition and the use thereof. The problems include the following:

no sufficiently thick resist film can be formed; bubbles are generated in the resist film; a sufficiently rectangular resist pattern cannot be obtained; the resist composition fails to be applied uniformly; footing occurs at the interface between the resist pattern and the substrate; the resist pattern has insufficient resistance (for example, against dry etching) in subsequent steps; the resist pattern has insufficient resolution; the resist pattern has insufficient LWR; the optimum exposure is large; the resist pattern has insufficient etching resistance; the resist pattern largely varies in pattern width; the resist pattern has a low aspect ratio; the process window is narrow; and the manufacturing yield is poor.

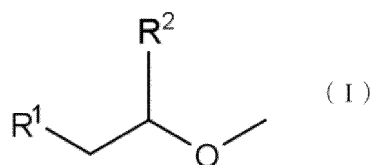
The present invention has been made based on the technical background as described above, and provides a resist composition and a method for producing a resist film using the resist composition.

[Solution to Problem]

[0006]

A resist composition according to the present invention comprises a polymer, a solvent represented by formula (I), and a compound represented by formula (II).

[C1]



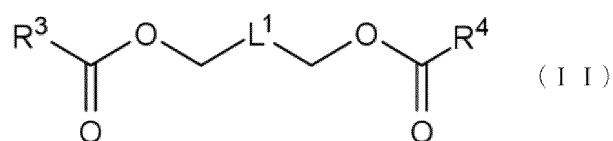
(where:

R<sup>1</sup> and R<sup>2</sup> are each independently C<sub>1-15</sub> alkyl or C<sub>1-15</sub> alkoxy, preferably C<sub>1-10</sub> alkyl, more preferably C<sub>1-5</sub> alkyl;

one or more H atoms in R<sup>1</sup> may each independently be replaced with -COOH or -OH; and

one or more non-adjacent methylene (-CH<sub>2</sub>-) groups in R<sup>1</sup> may each independently be replaced with -S-, -CO-, -CO-O-, -O-CO-, -O-CO-O-, -CH=CH-, or -C≡C-)

[C2]



(where:

R<sup>3</sup> and R<sup>4</sup> are each independently -CH=CH<sub>2</sub> or -CH≡CH, preferably -CH=CH<sub>2</sub>;

L<sup>1</sup> is a C<sub>1-20</sub> saturated aliphatic hydrocarbon group, preferably a C<sub>1-15</sub> saturated aliphatic hydrocarbon group, more preferably a C<sub>1-10</sub> saturated aliphatic hydrocarbon group;

one or more non-adjacent methylene (-CH<sub>2</sub>-) groups in L<sup>1</sup> may each independently be replaced with -O-, -S-, -CO-, -CO-O-, -O-CO-, -O-CO-O-, -CH=CH-, or -C≡C-)

[0007]

A method for producing a resist film according to the present invention comprises a step of applying the above-mentioned resist composition above a substrate, and preferably heating the resist composition.

[0008]

A resist film according to the present invention is produced by the method mentioned above, and has a film thickness of 100 to 300 μm, preferably 110 to 250 μm, more preferably 120 to 200 μm.

[0009]

A method for producing a resist pattern according to the present invention comprises the following steps:

producing a resist film by the method mentioned above;

exposing the resist film to light;

preferably heating the resist film before the exposure; and  
developing the exposed resist film.

[0010]

5 A method for producing a processed substrate according to the present  
invention comprises the following steps:  
producing a resist pattern by the method mentioned above; and  
performing a processing treatment with the resist pattern as a mask.

[0011]

10 A method for producing a device according to the present invention  
comprises the above-mentioned method for producing a processed  
substrate;  
preferably, further comprising a step of forming a wiring on the  
processed substrate; or  
preferably, wherein the device is a semiconductor device.

15 [0012]

The present invention relates to use of the above-mentioned resist  
composition for producing a resist film of 100  $\mu\text{m}$  or more in film thickness.

[Advantageous Effects of Invention]

[0013]

20 By using the resist composition according to the present invention, it is  
possible to desire one or more of the following effects:  
a sufficiently thick resist film can be formed; bubbles can be sufficiently kept  
from being generated in the resist film; a sufficiently rectangular resist  
pattern can be obtained; the resist composition can be applied sufficiently  
25 uniformly; footing can be sufficiently inhibited at the interface between the  
resist pattern and the substrate; the resist pattern has sufficient resistance  
(for example, against dry etching) in subsequent steps; the resist pattern  
has sufficient resolution; the resist pattern has sufficient LWR; the optimum  
exposure is sufficiently small; the resist pattern has sufficient etching  
30 resistance; the variation of the resist pattern in pattern width can be  
suppressed; the resist pattern has a sufficiently high aspect ratio; the

process window is sufficiently wide; and the manufacturing yield can be improved.

[Description of Embodiments]

[0014]

5

[Definitions]

In the present specification, the definitions and examples provided in this paragraph are used unless specifically stated otherwise.

10 The singular shall include the plural, and “a” or “the” means “at least one”. An element of a concept can be expressed by a plurality of types, and when an amount (e.g., % by mass or mol%) thereof is described, the amount thereof means a sum of the plurality of types thereof.

“And/or” includes all combinations of elements, and also includes use of either one of the elements.

15 When a numerical range is indicated using “to” or “-”, both end points are included in the range, and the units are common. For example, 5 to 25 mol% means 5 mol% or more and 25 mol% or less.

20 Descriptions such as “C<sub>x-y</sub>”, “C<sub>x</sub>-C<sub>y</sub>”, and “C<sub>x</sub>” mean the number of carbons in a molecule or a substituent. For example, C<sub>1-6</sub> alkyl means an alkyl chain (such as methyl, ethyl, propyl, butyl, pentyl, or hexyl) having from 1 to 6 carbons.

25 When the polymer includes multiple types of repeating units, these repeating units create a copolymer. The copolymer may be any of an alternating copolymer, a random copolymer, a block copolymer, a graft copolymer, or a mixture thereof. When a polymer or a resin is represented by a structural formula, n, m, or the like written in parentheses represents the number of repetitions.

The unit of temperature used is Celsius temperature (degree Celsius). For example, 20 degrees means 20 degrees Celsius.

30 An additive refers to a compound itself that has that function (e.g., a base generator refers to a compound itself that generates a base). There may also be an embodiment in which the compound is dissolved or dispersed in a solvent and is added to a composition.

The unit of parts by mass refers to a value based on all of the components (solid content) excluding the solvent in the composition.

[0015]

Hereinafter, embodiments of the present invention are described in detail.

[0016]

#### Resist Composition

A resist composition (hereinafter, referred to as a composition in some cases) according to the present invention comprises a polymer, a solvent represented by formula (I), and a compound represented by formula (II).

The resist composition refers to a resist composition that is capable of forming a resist film. In the present invention, the film thickness of a resist film that is formed from the resist composition is preferably 100 to 300  $\mu\text{m}$ , more preferably 110 to 250  $\mu\text{m}$ , still more preferably 120 to 200  $\mu\text{m}$ .

The kinematic viscosity of the composition according to the present invention is preferably 700 to 7,500 cSt, more preferably 2,200 to 7,000 cSt, still more preferably 3,000 to 6,500 cSt. In this regard, the kinematic viscosity is measured at 25°C with an automatic viscosity measuring apparatus. As the automatic viscosity measuring apparatus, for example, VMC-100 (RIGO CO., LTD.) can be used.

The viscosity of the composition according to the present invention is preferably 1,000 to 8,000 cP, more preferably 3,000 to 7,000 cP, still more preferably 4,000 to 6,500 cP. In this regard, the viscosity is measured at 25°C with a capillary viscometer.

While not bound by any theory, the kinematic viscosity and viscosity of the composition fall within the ranges mentioned above, thereby allowing the composition to be applied sufficiently uniformly.

The content of all of the components excluding the solvent (hereinafter, referred to as a solid content) in the resist composition according to the present invention is preferably 30 to 80 parts by mass, more preferably 40 to 75 parts by mass, still more preferably 50 to 70 parts by mass, based on 100 parts by mass of the composition.

The resist composition according to the present invention is preferably a negative resist composition.

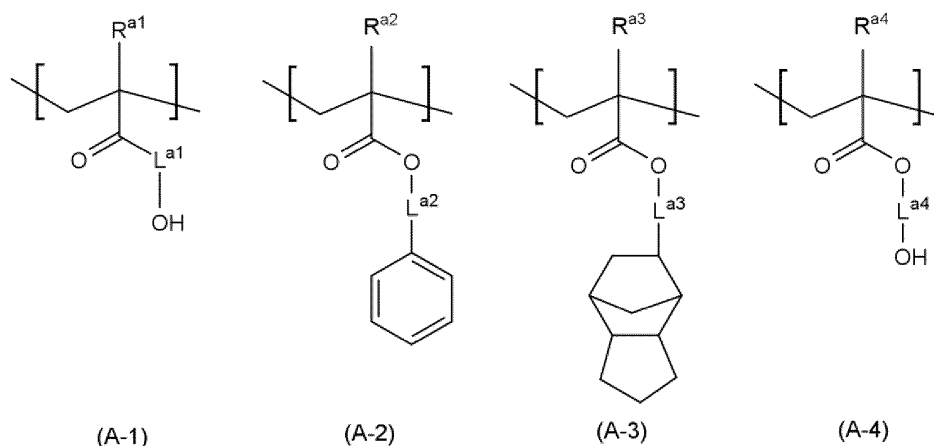
[0017]

Polymer

5 The composition according to the present invention comprises a polymer.

The polymer preferably comprises at least one of the repeating units represented by formulas (A-1) to (A-4).

[C3]



10

where:

$R^{a1}$  to  $R^{a4}$  are each independently hydrogen or  $C_{1-10}$  alkyl, preferably linear  $C_{1-10}$  alkyl, or branched or cyclic structure-containing  $C_{3-10}$  alkyl, more preferably linear  $C_{1-5}$  alkyl, still more preferably methyl.

15

$L^{a1}$  to  $L^{a4}$  are each independently a single bond or  $C_{1-10}$  alkylene, preferably a single bond, linear  $C_{1-10}$  alkylene, or branched or cyclic structure-containing  $C_{3-10}$  alkylene, more preferably a single bond, linear  $C_{1-5}$  alkylene or branched  $C_{3-5}$  alkylene, still more preferably a single bond, linear  $C_{1-3}$  alkylene or branched  $C_3$  alkylene.

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[0018]

These repeating units are appropriately blended depending on the purpose, the blending ratio thereof is not particularly limited.

In the polymer, the numbers of repeating units of formulas (A-1), (A-2), (A-3), and (A-4) are represented respectively by  $n_{a1}$ ,  $n_{a2}$ ,  $n_{a3}$ , and  $n_{a4}$ .

$n_{a1}/(n_{a1} + n_{a2} + n_{a3} + n_{a4})$  is preferably 0% to 60%, more preferably 5% to 50%, still more preferably 10% to 40%, even more preferably 25% to 35%.

5  $n_{a2}/(n_{a1} + n_{a2} + n_{a3} + n_{a4})$  is preferably 0% to 60%, more preferably 10% to 60%, still more preferably 25% to 55%, even more preferably 30% to 50%.

$n_{a3}/(n_{a1} + n_{a2} + n_{a3} + n_{a4})$  is preferably 0% to 50%, more preferably 2% to 30%, still more preferably 5% to 15%, even more preferably 7% to 13%.

10  $n_{a4}/(n_{a1} + n_{a2} + n_{a3} + n_{a4})$  is preferably 0% to 50%, more preferably 2% to 40%, still more preferably 10% to 20%, even more preferably 12% to 18%.

Preferably,  $n_{a1} + n_{a2} > 0\%$ , that is, at least one of  $n_{a1}$  and  $n_{a2}$  is greater than 0%. More preferably,  $n_{a1}$  is greater than 0%.

The polymer can also comprise a repeating unit other than the repeating units represented by formulas (A-1), (A-2), (A-3), and (A-4). In this regard,

15 the total number  $n_{total}$  of all the repeating units comprised in the polymer preferably satisfies the following formula:

$$80\% \leq (n_{a1} + n_{a2} + n_{a3} + n_{a4})/n_{total} \leq 100\%.$$

$(n_{a1} + n_{a2} + n_{a3} + n_{a4})/n_{total}$  is more preferably 90% to 100%, still more preferably 95% to 100%.  $(n_{a1} + n_{a2} + n_{a3} + n_{a4})/n_{total} = 100\%$ , that is,

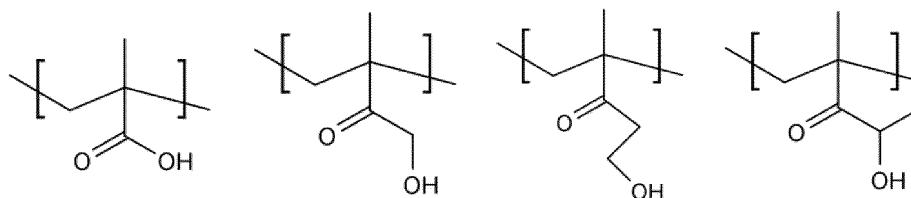
20 including no repeating unit other than the repeating units represented by formulas (A-1), (A-2), (A-3), and (A-4) is also a preferred embodiment of the present invention.

[0019]

Specific examples of the repeating unit represented by formula (A-1) are

25 as follows.

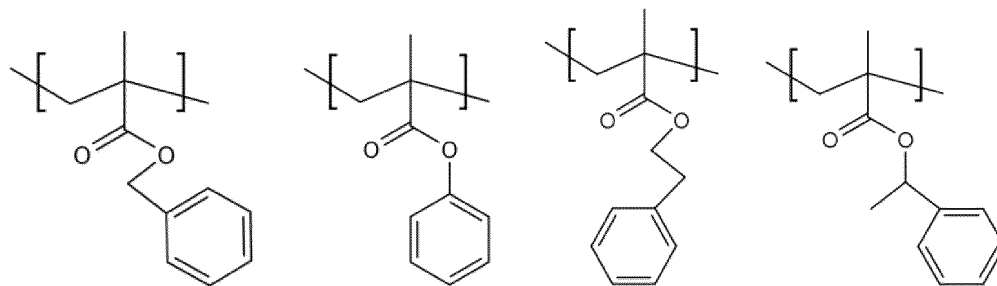
[C4]



[0020]

Specific examples of the repeating unit represented by formula (A-2) are as follows.

[C5]

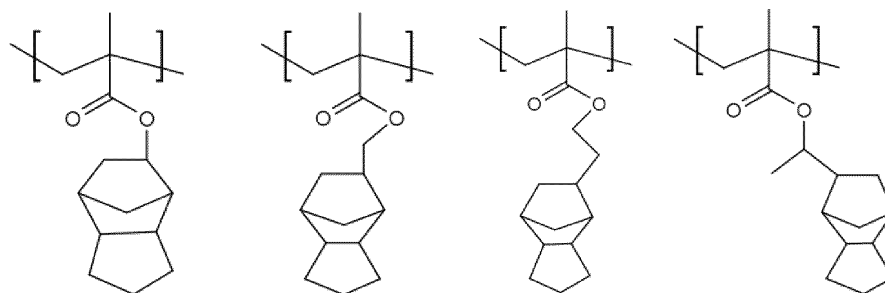


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[0021]

Specific examples of the repeating unit represented by formula (A-3) are as follows.

[C6]

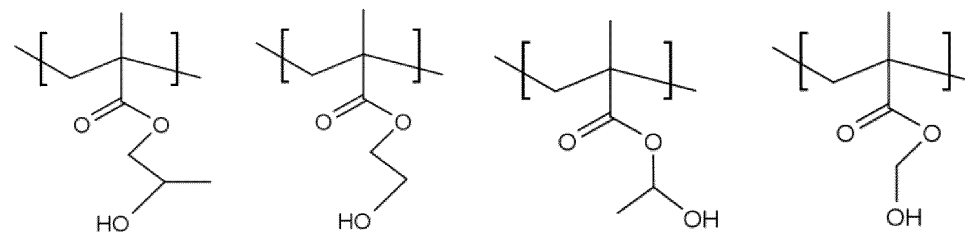


10

[0022]

Specific examples of the repeating unit represented by formula (A-4) are as follows.

[C7]



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[0023]

The mass average molecular weight ( $M_w$ ) of the polymer is preferably 2,000 to 200,000, more preferably 4,000 to 200,000, still more preferably 8,000 to 30,000. In this regard,  $M_w$  can be determined in terms of polystyrene by gel permeation chromatography. For the measurement, it is a preferred example to use a GPC column at 40°C, an elution solvent of tetrahydrofuran at 0.6 mL/min, and monodisperse polystyrene as a standard.

[0024]

The polymer may have one, or two or more components.

The content of the polymer is preferably 30 to 90 parts by mass, more preferably 40 to 80 parts by mass, still more preferably 50 to 70 parts by mass, based on 100 parts by mass of the solid content.

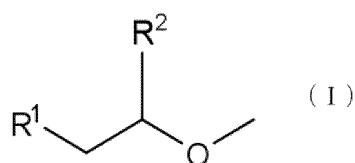
The composition according to the present invention may comprise a polymer (hereinafter, referred to as other polymer) including none of the repeating units represented by formulae (A-1) to (A-4). The amount of the other polymer (if more than one, the sum thereof) is, based on 100 parts by mass of the solid content, preferably 0 to 20 parts by mass, more preferably 0 to 10 parts by mass, still more preferably 0 to 5 parts by mass, and even more preferably, the composition according to the present invention comprises no other polymer (0 parts by mass).

[0025]

Solvent

The composition according to the present invention comprises a solvent represented by formula (I). The boiling point of the solvent is preferably 130 to 300°C, more preferably 140 to 250°C, still more preferably 150 to 200°C.

[C8]



where:

$R^1$  and  $R^2$  are each independently  $C_{1-15}$  alkyl or  $C_{1-15}$  alkoxy, preferably linear  $C_{1-15}$  alkyl, branched or cyclic structure-containing  $C_{3-15}$  alkyl, linear  $C_{1-15}$  alkoxy, or branched or cyclic structure-containing  $C_{3-15}$  alkoxy, more preferably linear  $C_{1-10}$  alkyl, still more preferably linear  $C_{1-5}$  alkyl.

5 One or more H atoms in  $R^1$  may each independently be replaced with -COOH or -OH, preferably, is replaced with -OH or not replaced.

One or more non-adjacent methylene ( $-CH_2-$ ) groups in  $R^1$  may each independently be replaced with -S-, -CO-, -CO-O-, -O-CO-, -O-CO-O-, -CH=CH-, or  $-C\equiv C-$ , preferably, is replaced with -CO-O- or -O-CO- or not

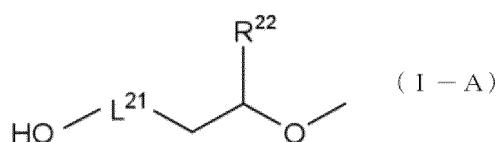
10 replaced.  
[0026]

While not bound by any theory, the composition according to the present invention comprises the solvent represented by formula (I), thereby allowing a thick-film resist capable of pattern formation to be produced without

15 generating bubbles in the composition.  
[0027]

As a preferred embodiment, the solvent represented by formula (I) can be further represented by formula (I-A) or formula (I-B).

[C9]

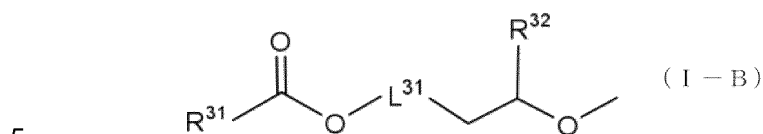


where  $R^{22}$  is linear  $C_{1-15}$  alkyl, branched or cyclic structure-containing  $C_{3-15}$  alkyl, linear  $C_{1-15}$  alkoxy, or branched or cyclic structure-containing  $C_{3-15}$  alkoxy, preferably linear  $C_{1-10}$  alkyl, more preferably linear  $C_{1-5}$  alkyl, still more preferably methyl.

25  $L^{21}$  is linear  $C_{1-15}$  alkylene, or branched or cyclic structure-containing  $C_{3-15}$  alkylene, preferably linear  $C_{1-10}$  alkylene, more preferably linear  $C_{1-5}$  alkylene, still more preferably methylene.

One or more non-adjacent methylene (-CH<sub>2</sub>-) groups in L<sup>21</sup> may be each independently replaced with -S-, -CO-, -CO-O-, -O-CO-, -O-CO-O-, -CH=CH-, or -C≡C-, and are preferably not replaced.

[C10]



where, R<sup>31</sup> is linear C<sub>1-6</sub> alkyl, or branched or cyclic structure-containing C<sub>3-6</sub> alkyl, preferably linear C<sub>1-3</sub> alkyl or branched C<sub>3</sub> alkyl, more preferably linear C<sub>1-3</sub> alkyl, still more preferably methyl.

10 R<sup>32</sup> is linear C<sub>1-15</sub> alkyl, branched or cyclic structure-containing C<sub>3-15</sub> alkyl, linear C<sub>1-15</sub> alkoxy, or branched or cyclic structure-containing C<sub>3-15</sub> alkoxy, preferably linear C<sub>1-10</sub> alkyl, more preferably linear C<sub>1-5</sub> alkyl, still more preferably methyl.

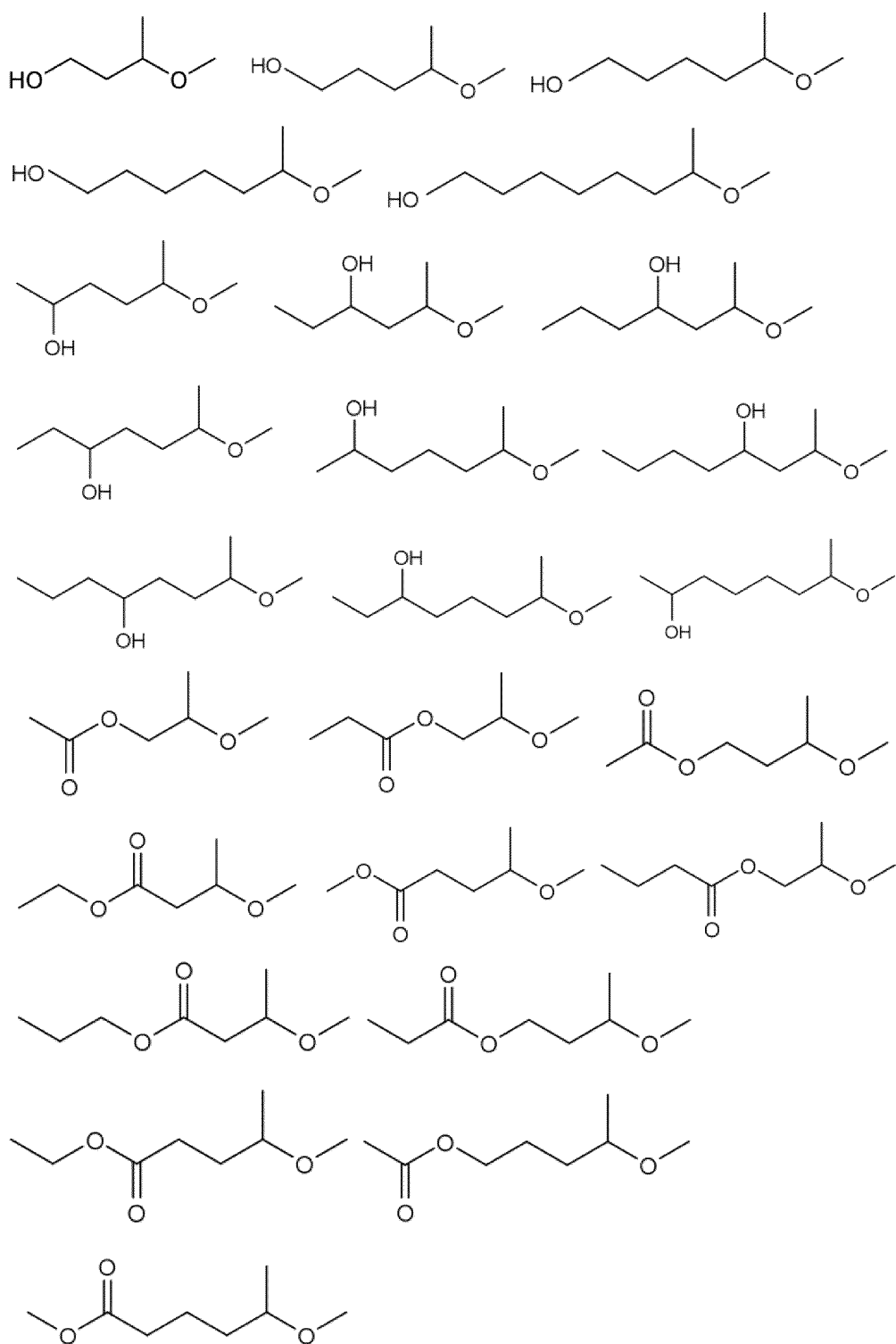
15 L<sup>31</sup> is linear C<sub>1-6</sub> alkylene, or branched or cyclic structure-containing C<sub>3-6</sub> alkylene, preferably linear C<sub>1-3</sub> alkylene or branched C<sub>3</sub> alkylene, more preferably linear C<sub>1-3</sub> alkylene, still more preferably methylene.

One or more non-adjacent methylene (-CH<sub>2</sub>-) groups in L<sup>31</sup> may be each independently replaced with -S-, -CO-, -CO-O-, -O-CO-, -O-CO-O-, -CH=CH-, or -C≡C-, and are preferably not replaced.

[0028]

20 Specific examples of the solvent are as follows.

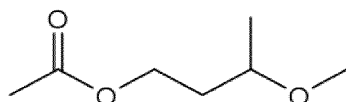
[C11]



[0029]

By way of example, how the following compound is read from formula (I) is described in detail.

[C12]

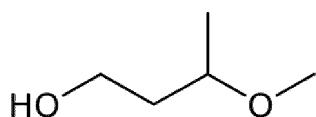


In the compound mentioned above,  $R^1$  is  $C_3$  alkyl (n-propyl) with one methylene ( $-CH_2-$ ) group is replaced with  $-CO-O-$ , and  $R^2$  is  $C_1$  alkyl (methyl).

[0030]

By way of another example, how the following compound is read from formula (I) is described in detail.

[C13]



In the compound mentioned above,  $R^1$  is  $C_1$  alkyl (methyl) with one H being replaced with  $-OH$ , and  $R^2$  is  $C_1$  alkyl (methyl).

[0031]

The content of the solvent represented by formula (I) is, based on 100 parts by mass of the solid content, preferably 30 to 95 parts by mass, more preferably 40 to 90 parts by mass; still more preferably 50 to 80 parts by mass.

[0032]

The composition according to the present invention may comprise a solvent (hereinafter, referred to as other solvent), other than the solvent represented by formula (I). The content of the other solvent is, based on 100 parts by mass of the solid content, preferably 0 to 20 parts by mass, more preferably 0 to 10 parts by mass, still more preferably 0 to 5 parts by mass, and even more preferably, the composition according to the present invention comprises no other solvent (0 parts by mass).

[0033]

Examples of the other solvent include water, n-pentane, i-pentane, n-hexane, i-hexane, n-heptane, i-heptane, 2,2,4-trimethylpentane, n-octane, i-octane, cyclohexane, methylcyclohexane, benzene, toluene, xylene,  
5 ethylbenzene, trimethylbenzene, methylethylbenzene, n-propylbenzene, i-propylbenzene, diethylbenzene, i-butylbenzene, triethylbenzene, di-i-propylbenzene, n-amyl naphthalene, trimethylbenzene, methanol, ethanol, n-propanol, i-propanol, n-butanol, i-butanol, sec-butanol, t-butanol, n-pentanol, i-pentanol, 2-methylbutanol, sec-pentanol, t-pentanol, n-hexanol,  
10 2-methylpentanol, sec-hexanol, 2-ethylbutanol, sec-heptanol, 3-heptanol, n-octanol, 2-ethylhexanol, sec-octanol, n-nonyl alcohol, 2,6-dimethylheptan-4-ol, n-decanol, sec-undecyl alcohol, trimethylnonyl alcohol, sec-tetradecyl alcohol, sec-heptadecyl alcohol, phenol, cyclohexanol, methylcyclohexanol, 3,3,5-trimethylcyclohexanol, benzyl alcohol, phenylmethyl carbinol,  
15 diacetone alcohol, cresol, ethylene glycol, propylene glycol, 1,3-butylene glycol, 2,4-pentanediol, 2-methylpentane-2,4-diol, 2,5-hexanediol, 2,4-heptanediol, 2-ethylhexane-1,3-diol, diethylene glycol, dipropylene glycol, triethylene glycol, tripropylene glycol, glycerin, acetone, methyl ethyl ketone, methyl-n-propyl ketone, methyl-n-butyl ketone, diethyl ketone,  
20 methyl-i-butyl ketone, methyl-n-pentyl ketone, ethyl-n-butyl ketone, methyl-n-hexyl ketone, di-i-butyl ketone, trimethylnonanone, cyclohexanone, cyclopentanone, methylcyclohexanone, 2,4-pentanedione, acetylacetone, diacetone alcohol, acetophenone, fenchone, ethyl ether, i-propyl ether, n-butyl ether, n-hexyl ether, 2-ethylhexyl ether, ethylene oxide,  
25 1,2-propylene oxide, dioxolane, 4-methyldioxolane, dioxane, dimethyl dioxane, ethylene glycol monomethyl ether, ethylene glycol monoethyl ether, ethylene glycol diethyl ether, ethylene glycol mono-n-butyl ether, ethylene glycol mono-n-hexyl ether, ethylene glycol monophenyl ether, ethylene glycol mono-2-ethylbutyl ether, ethylene glycol dibutyl ether,  
30 diethylene glycol monomethyl ether, diethylene glycol monoethyl ether, diethylene glycol diethyl ether, diethylene glycol mono-n-butyl ether, diethylene glycol di-n-butyl ether, diethylene glycol mono-n-hexyl ether,

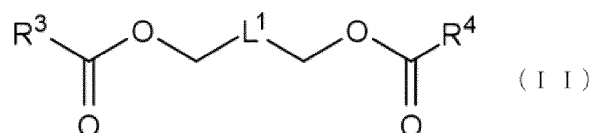
ethoxy triglycol, tetraethylene glycol di-n-butyl ether, propylene glycol monomethyl ether (PGME), propylene glycol monoethyl ether, propylene glycol monopropyl ether, propylene glycol monobutyl ether, dipropylene glycol monomethyl ether, dipropylene glycol monoethyl ether, dipropylene glycol monopropyl ether, dipropylene glycol monobutyl ether, tripropylene glycol monomethyl ether, tetrahydrofuran, 2-methyltetrahydrofuran; ester-based solvents such as diethyl carbonate, methyl acetate, ethyl acetate,  $\gamma$ -butyrolactone,  $\gamma$ -valerolactone, n-propyl acetate, i-propyl acetate, n-butyl acetate, i-butyl acetate, sec-butyl acetate, n-pentyl acetate, sec-pentyl acetate, methylpentyl acetate, 2-ethylbutyl acetate, 2-ethylhexyl acetate, benzyl acetate, cyclohexyl acetate, methylcyclohexyl acetate, n-nonyl acetate, methyl acetoacetate, ethyl acetoacetate, ethylene glycol monomethyl ether acetate, ethylene glycol monoethyl ether acetate, diethylene glycol monomethyl ether acetate, diethylene glycol monoethyl ether acetate, diethylene glycol mono-n-butyl ether acetate, propylene glycol monomethyl ether acetate (PGMEA), propylene glycol monoethyl ether acetate, propylene glycol monopropyl ether acetate, propylene glycol monobutyl ether acetate, dipropylene glycol monomethyl ether acetate, dipropylene glycol monoethyl ether acetate, glycol diacetate, ethyl propionate, n-butyl propionate, i-amyl propionate, diethyl oxalate, di-n-butyl oxalate, methyl lactate, ethyl lactate (EL),  $\gamma$ -butyrolactone, n-butyl lactate, n-amyl lactate, diethyl malonate, dimethyl phthalate, and diethyl phthalate; N-methylformamide, N,N-dimethylformamide, N,N-diethylformamide, acetamide, N-methylacetamide, N,N-dimethylacetamide, N-methylpropionamide, N-methylpyrrolidone, dimethyl sulfide, diethyl sulfide, thiophene, tetrahydrothiophene, dimethyl sulfoxide, sulfolane, 1,3-propanesultone, or a mixture of any thereof.

[0034]

Compound

30 The composition according to the present invention comprises a compound represented by formula (II).

[C14]



where:

$\text{R}^3$  and  $\text{R}^4$  are each independently  $-\text{CH}=\text{CH}_2$  or  $-\text{CH}\equiv\text{CH}$ , preferably  $-\text{CH}=\text{CH}_2$ .

5  $\text{L}^1$  is a  $\text{C}_{1-20}$  saturated aliphatic hydrocarbon group, preferably a linear  $\text{C}_{1-20}$  saturated aliphatic hydrocarbon group, or a branched or cyclic structure-containing  $\text{C}_{3-20}$  saturated aliphatic hydrocarbon group, more preferably a linear  $\text{C}_{1-15}$  saturated aliphatic hydrocarbon group, or a branched or cyclic structure-containing  $\text{C}_{3-15}$  saturated aliphatic hydrocarbon group, still more preferably a linear  $\text{C}_{1-10}$  saturated aliphatic hydrocarbon group or a cyclic structure-containing  $\text{C}_{3-10}$  saturated aliphatic hydrocarbon group.

One or more non-adjacent methylene ( $-\text{CH}_2-$ ) groups in  $\text{L}^1$  may be each independently replaced with  $-\text{O}-$ ,  $-\text{S}-$ ,  $-\text{CO}-$ ,  $-\text{CO}-\text{O}-$ ,  $-\text{O}-\text{CO}-$ ,  $-\text{O}-\text{CO}-\text{O}-$ ,  $-\text{CH}=\text{CH}-$ , or  $-\text{C}\equiv\text{C}-$ , and are preferably replaced with  $-\text{O}-$  or not replaced.

15 [0035]

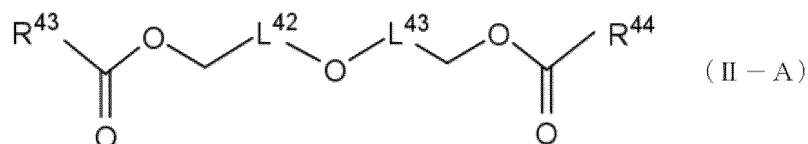
While not bound by any theory, the composition according to the present invention comprises the solvent represented by formula (I) and the compound represented by formula (II), thereby allowing a thick-film resist capable of pattern formation to be produced without generating bubbles in the composition.

20

[0036]

As a preferred embodiment, the compound represented by formula (II) can be further represented by formula (II-A) or formula (II-B).

[C15]



25

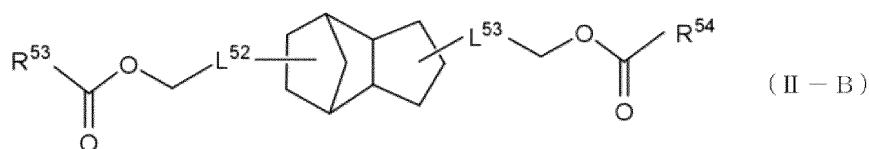
where:

$R^{43}$  and  $R^{44}$  are each independently  $-\text{CH}=\text{CH}_2$  or  $-\text{CH}\equiv\text{CH}$ , preferably  $-\text{CH}=\text{CH}_2$ .

$L^{42}$  and  $L^{43}$  are each independently linear  $\text{C}_{1-9}$  alkylene, or branched or cyclic structure-containing  $\text{C}_{3-9}$  alkylene, preferably linear  $\text{C}_{1-9}$  alkylene or branched  $\text{C}_{3-9}$  alkylene, more preferably linear  $\text{C}_{1-6}$  alkylene, still more preferably linear butylene.

One or more non-adjacent methylene ( $-\text{CH}_2-$ ) groups in  $L^{42}$  and  $L^{43}$  may be each independently replaced with  $-\text{O}-$ ,  $-\text{S}-$ ,  $-\text{CO}-$ ,  $-\text{CO}-\text{O}-$ ,  $-\text{O}-\text{CO}-$ ,  $-\text{O}-\text{CO}-\text{O}-$ ,  $-\text{CH}=\text{CH}-$ , or  $-\text{C}\equiv\text{C}-$ , and are preferably replaced with  $-\text{O}-$ . As a further preferred embodiment, one methylene ( $-\text{CH}_2-$ ) group in  $L^{42}$  and  $L^{43}$  is replaced with  $-\text{O}-$ .

[C16]



where:

$R^{53}$  and  $R^{54}$  are each independently  $-\text{CH}=\text{CH}_2$  or  $-\text{CH}\equiv\text{CH}$ , preferably  $-\text{CH}=\text{CH}_2$ .

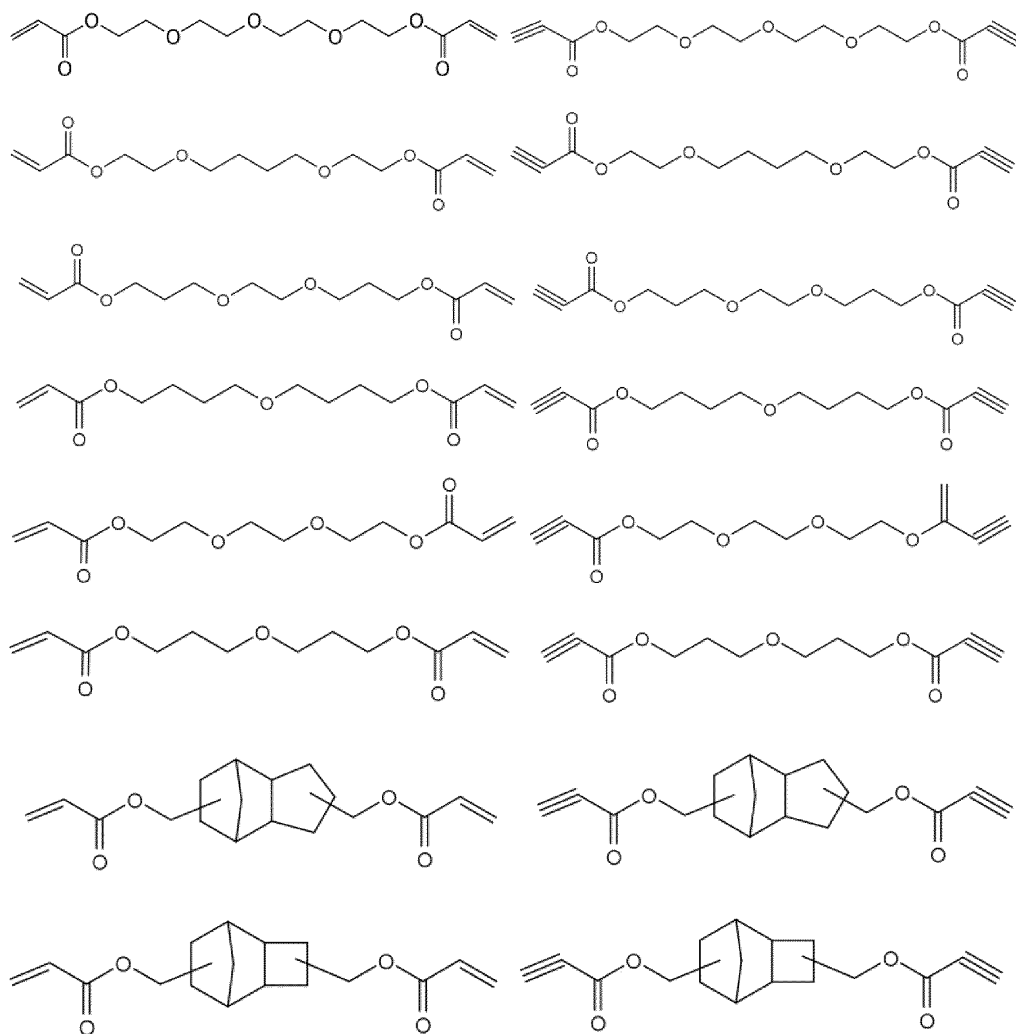
$L^{52}$  and  $L^{53}$  are each independently a single bond, linear  $\text{C}_{1-5}$  alkylene, or branched or cyclic structure-containing  $\text{C}_{3-5}$  alkylene, preferably a single bond, linear  $\text{C}_{1-5}$  alkylene, or branched  $\text{C}_{3-5}$  alkylene, more preferably a single bond or linear  $\text{C}_{1-3}$  alkylene, still more preferably a single bond.

One or more non-adjacent methylene ( $-\text{CH}_2-$ ) groups in  $L^{52}$  and  $L^{53}$  may be each independently replaced with  $-\text{O}-$ ,  $-\text{S}-$ ,  $-\text{CO}-$ ,  $-\text{CO}-\text{O}-$ ,  $-\text{O}-\text{CO}-$ ,  $-\text{O}-\text{CO}-\text{O}-$ ,  $-\text{CH}=\text{CH}-$ , or  $-\text{C}\equiv\text{C}-$ , and are preferably not replaced.

[0037]

Specific examples of formula (II) are as follows.

[C17]

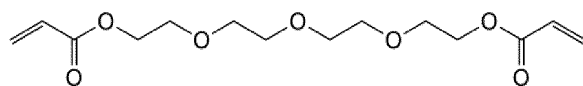


[0038]

By way of example, how the following compound is read from formula (II) is described in detail.

5

[C18]



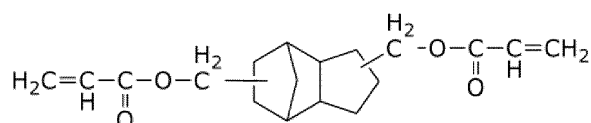
In the compound mentioned above,  $R^3$  and  $R^4$  are  $-\text{CH}=\text{CH}_2$ , and  $L^1$  is a  $\text{C}_9$  saturated aliphatic hydrocarbon group (linear  $\text{C}_9$  saturated aliphatic

hydrocarbon group) with three non-adjacent methylene (-CH<sub>2</sub>-) groups replaced with -O-.

[0039]

By way of another example, how the following compound is read from formula (II) is described in detail.

[C19]



In the compound mentioned above, R<sup>3</sup> and R<sup>4</sup> are -CH=CH<sub>2</sub>, and L<sup>1</sup> is a C<sub>10</sub> saturated aliphatic hydrocarbon group including a cyclic structure.

[0040]

The compound represented by formula (II) may have one, or two or more compounds.

The composition according to the present invention preferably comprises two or more compounds that are represented by formula (II) and different in structure from each other, more preferably comprises two compounds that are represented by formula (II) and different in structure from each other.

[0041]

The ratio by mass of the compound represented by formula (II) to the polymer is preferably 0.15 to 0.85, more preferably 0.20 to 0.80, still more preferably 0.30 to 0.75.

[0042]

#### Polymerization Initiator

The composition according to the present invention can comprise a polymerization initiator. The polymerization initiator can, in a preferred embodiment, comprise at least one radical photoinitiator that is activated by light absorption of radiation at 360 to 440 nm. While not bound any theory, the radical photoinitiator with a broad absorption of 360 to 440 nm can undergo photodegradation at these wavelengths and cleave to produce radicals, and allows a longer penetration depth into the composition

according to the present invention when the composition is applied for coating as a thick resist film and irradiated at the time of patterning.

[0043]

5 The content of the polymerization initiator is preferably 0.25 to 5.0 parts by mass, more preferably 0.5 to 4.0 parts by mass, based on 100 parts by mass of the solid content.

[0044]

10 Examples of the radical photoinitiator include arylacylphosphine oxide-based photoinitiators. Examples of the arylacylphosphine oxide-based photoinitiators include mono(arylacyl)phosphine oxides, di(arylacyl)phosphine oxides, tri(arylacyl)phosphine oxides, or mixtures of different acylphosphine oxide-based photoinitiators.

[0045]

15 The polymerization initiator can preferably comprise a photoinitiator other than the arylacylphosphine oxide-based photoinitiators and a sensitizer. Examples of the photoinitiator and the sensitizer include 1,2-octanedione, 1-[4-(phenylthio)phenyl]-, 2-(O-benzoyloxime)- (OXE-01), ethanone, 1-[9-ethyl-6-(2-methylbenzoyl)-9H-carbazol-3-yl]-, 1-(O-acetyl oxime)- (OXE-02), an oxime ester photoacid generator, fluorinated (OXE-03), 2-methyl-1-[4-(methylthio)phenyl]-2-morpholinopropan-1-one (Irgacure (registered trademark) 907), halogenated-2,5-cyclohexadienone, benzophenone, alkylaryl ketone or diketone species, or a mixture of any of these compounds.

[0046]

25 Radical Scavenger

The composition according to the present invention can preferably comprise a radical scavenger. The radical scavenger allows scumming of the resist pattern to be prevented.

[0047]

30 Examples of the radical scavenger include scavengers that are stable analogs of five- or six-membered heterocyclic structures including stable

nitroxide radicals and stable analogs of alkyl chains including stable nitroxide radicals.

[0048]

Specific examples of the radical scavenger include 2,2,6,6-tetramethyl-1-  
5 piperidinyloxy radicals (TEMPO), 2,2,6,6-tetraethyl-1-piperidinyloxy  
radicals, 2,2,6,6-tetramethyl-4-oxo-1-piperidinyloxy radicals, 2,2,5,5-  
tetramethyl-1-pyrrolidinyloxy radicals, 1,1,3,3-tetramethyl-2-isoindolinyloxy  
radicals, and N,N-di-tert-butylamine-oxy radicals. Above all, the examples  
include 2,2,6,6-tetramethyl-1-piperidinyloxy radicals, 2,2,6,6-tetramethyl-4-  
10 oxo-1-piperidinyloxy radicals, or combinations thereof.

[0049]

The content of the radical scavenger is preferably 0.01 to 0.1 parts by  
mass, more preferably 0.02 to 0.08 parts by mass, based on 100 parts by  
mass of the solid content.

15 [0050]

Surfactant

The composition according to the present invention can comprise a  
surfactant. The surfactant allows the coatability of the composition to be  
improved.

20 Examples of the surfactant include a nonionic surfactant, an anionic  
surfactant, and an amphoteric surfactant.

[0051]

Examples of the nonionic surfactant include polyoxyethylene alkyl ethers  
such as polyoxyethylene lauryl ethers, polyoxyethylene oleyl ethers, and  
25 polyoxyethylene cetyl ethers, polyoxyethylene fatty acid diesters, polyoxy  
fatty acid monoesters, polyoxyethylene polyoxypropylene block polymers,  
acetylene alcohols, acetylene glycols, polyethoxylates of acetylene  
alcohols, acetylene glycol derivatives such as polyethoxylates of acetylene  
glycols, fluorine-containing surfactants, for example, Fluorad (3M),  
30 MEGAFACE (DIC), and Surflon (AGC Inc.), or organosiloxane surfactants,  
for example, KF-53 (Shin-Etsu Chemical Co., Ltd.). Examples of the  
acetylene glycol include 3-methyl-1-butyne-3-ol, 3-methyl-1-pentyne -3-ol,

3,6-dimethyl-4-octyne-3,6-diol, 2,4,7,9-tetramethyl-5-decyne-4,7-diol, 3,5-dimethyl-1-hexyne-3-ol, 2,5-dimethyl-3-hexyne-2,5-diol, and 2,5-dimethyl-2,5-hexanediol.

[0052]

5        Examples of the anionic surfactant include ammonium salts or organic amine salts of alkyl diphenyl ether disulfonic acid, ammonium salts or organic amine salts of alkyl diphenyl ether sulfonic acid, ammonium salts or organic amine salts of alkyl benzene sulfonic acid, ammonium salts or organic amine salts of polyoxyethylene alkyl ether sulfuric acid, and  
10       ammonium salts or organic amine salts of alkyl sulfuric acid.

[0053]

      Examples of the amphoteric surfactant include 2-alkyl-N-carboxymethyl-N-hydroxyethyl imidazolium betaine and lauric acid amidopropyl hydroxysulfone betaine.

15       [0054]

      The surfactants can be used alone, or two or more thereof can be used in mixture.

      The content of the surfactant is preferably 0.01 to 5 parts by mass, more preferably 0.05 to 1 parts by mass, based on 100 parts by mass of the solid  
20       content.

[0055]

Additive

      The composition according to the present invention can comprise an additive besides the components described above. The additive is  
25       preferably selected from at least one of the group consisting of a catalyst, a surface smoothing agent, a plasticizer, a dye, a contrast enhancer, an acid, a basic compound, a radical generator, nanoparticles, a binding enhancer, a silane coupling agent, an anti-foaming agent, and a defoaming agent.

      The content of the additive is preferably 0.01 to 10 parts by mass, more preferably 0.1 to 2 parts by mass, based on 100 parts by mass of the solid  
30       content. Including no additive (0 parts by mass) is also a preferred embodiment of the composition according to the present invention.

[0056]

The acid can be used to adjust the pH value of the composition or to improve the solubility of the additive component. The acid to be used is not particularly limited, and examples thereof include formic acid, acetic acid, propionic acid, benzoic acid, phthalic acid, salicylic acid, lactic acid, malic acid, citric acid, oxalic acid, malonic acid, succinic acid, fumaric acid, maleic acid, aconitic acid, glutaric acid, adipic acid, p-toluenesulfonic acid, camphorsulfonic acid, hydrates of any of these acids, or combinations of any thereof.

[0057]

While not bound by any theory, the basic compound has the effect of inhibiting the diffusion of an acid generated in an exposed part, and is considered to contribute to an improvement in resolution.

[0058]

Examples of the basic compound preferably include C<sub>1-16</sub> primary aliphatic amine compounds, C<sub>2-32</sub> secondary aliphatic amine compounds, C<sub>3-48</sub> tertiary aliphatic amine compounds, C<sub>6-30</sub> aromatic amine compounds, or C<sub>5-30</sub> heterocyclic amine compounds.

[0059]

Specific examples of the basic compound include ethylamine, n-octylamine, n-heptylamine, ethylenediamine, triethylamine, tri-n-octylamine, diethylamine, triethanolamine, tris[2-(2-methoxyethoxy)ethyl]amine, 1,8-diazabicyclo[5.4.0]-7-undecene, 1,5-diazabicyclo[4.3.0]-5-nonene, 7-methyl-1,5,7-triazabicyclo[4.4.0]deca-5-ene, and 1,5,7-triazabicyclo[4.4.0]deca-5-ene, or combinations of any of these compounds.

[0060]

The base dissociation constant pK<sub>b</sub> (H<sub>2</sub>O) of the basic compound is preferably -12 to 5, more preferably 1 to 4.

[0061]

The molecular weight of the basic compound is preferably 20 to 500, more preferably 60 to 400.

[0062]

The addition of a catalyst can accelerate curing of the composition according to the present invention. Examples of useful catalysts include Lewis acids such as boron alkyl, aluminum alkyl, tin alkyl, zinc alkyl, aryl, or carboxylate, Bronsted acids such as carboxylic acids, bases such as primary, secondary, tertiary amines or phosphazenes, and metal salts such as Pd, Pt, Al, B, Sn, or Zn salts of carboxylates, acetylacetonates, or alkoxylates.

[0063]

The nanoparticles may be selected from nitrides, titanates, diamonds, oxides, sulfides, sulfites, sulfates, silicates, and carbides, which can be optionally surface-modified with the use of capping agents. The particle sizes of the nanoparticles may be, for example, 1 to 100 nm, 1 to 50 nm, or 1 to 25 nm. The particle sizes can be measured by any standard method known to those skilled in the art.

[0064]

The binding enhancer has the effect of preventing a coating film from being peeled off from a substrate due to stress applied when applying the composition according to the present invention to the substrate to form the coating film and curing the coating film by heating. As the binding enhancer, imidazole, silane coupling agents, and the like are preferred. 2-hydroxybenzimidazole, 2-hydroxyethylbenzimidazole, benzimidazole, 2-hydroxyimidazole, imidazole, 2-mercaptoimidazole, 2-aminoimidazole, and the like can be used as the imidazoles.

[0065]

As the silane coupling agent, epoxysilane coupling agents, aminosilane coupling agents, mercaptosilane coupling agents, and the like can be used. Specifically, 3-glycidoxypropyltrimethoxysilane, 3-glycidoxypropyltriethoxysilane, N-2-(aminoethyl)-3-aminopropyltrimethoxysilane, N-2-(aminoethyl)-3-aminopropyltriethoxysilane, 3-aminopropyltrimethoxysilane, 3-aminopropyltriethoxysilane, 3-ureidopropyltriethoxysilane, 3-

chloropropyltriethoxysilane, 3-mercaptopropyltrimethoxysilane, 3-isocyanatopropyltriethoxysilane, and the like can be used.

[0066]

5 As the anti-foaming agent, alcohols (C<sub>1-18</sub>), higher fatty acids such as oleic acid and stearic acid, higher fatty acid esters such as glycerin monolaurate, polyethers such as polyethylene glycols and polypropylene glycols, silicone compounds such as dimethyl silicone oil, alkyl-modified silicone oil, and fluoro-silicone oil, and the like can be used.

[0067]

#### 10 Method for Producing Resist Film

A method for producing a resist film according to the present invention comprises the following steps:

(1) applying the composition according to the present invention above a substrate; and

15 (2) preferably heating the composition to form a resist film having a film thickness of 100 to 300  $\mu\text{m}$ .

Hereinafter, an embodiment of the production method according to the present invention is described.

[0068]

#### 20 Step (1)

The composition according to the present invention is applied by an appropriate method above the substrate (for example, a silicon/silicon dioxide coated substrate, a silicon nitride substrate, a silicon wafer substrate, a glass substrate, a metal substrate such as Cu or Ti, and the like). In this regard, in the present invention, the term of above includes a case of being formed directly on and a case of being formed with another layer interposed. For example, a planarization film or a resist lower layer film may be formed directly on the substrate, and the composition according to the present invention may be applied directly on the planarization film or  
25 the resist lower layer film. An embodiment of applying the composition according to the present invention directly on the substrate (without any other layers interposed) is more preferred. The method for the application is  
30

not particularly limited, and examples thereof include a method by application with a spinner or a coater.

[0069]

Step (2)

5       After the application of the composition, the composition is heated to form a resist film having a film thickness of 100 to 300  $\mu\text{m}$ . The heating in step (2) is performed, for example, with a hot plate. The heating temperature is preferably 100 to 250°C, more preferably 100 to 200°C, still more preferably 100 to 160°C. The temperature herein is in a heating atmosphere, for example, a heating surface temperature of a hot plate. The heating time is preferably 30 to 300 seconds, more preferably 60 to 240 seconds. The heating is preferably performed in the atmosphere or a nitrogen gas atmosphere.

[0070]

15       In the method for producing a resist film according to the present invention, preferably after step (2), double coating of repeatedly performing steps (1) and (2) can be performed. Thus, the resist film can be easily made thicker.

[0071]

20       The film thickness of the resist film is selected depending on the purpose. The thickness of the resist film is preferably 100 to 300  $\mu\text{m}$ , more preferably 110 to 250  $\mu\text{m}$ , still more preferably 120 to 200  $\mu\text{m}$ .

[0072]

25       A resist pattern can be produced by a method further comprising the following steps:

(3) exposing the resist film to light; and

(4) developing the resist film.

For clarity, steps (1) and (2) are performed before step (3). The number in () indicating the step means the order. The same applies hereinafter.

30       [0073]

Step (3)

The resist film is exposed to light through a predetermined mask. The wavelength of the light for use in the exposure is not particularly limited. The exposure is preferably performed with light of 360 to 440 nm in wavelength. Specifically, a high-pressure mercury lamp (wavelength: 436 nm, 405 nm, 365 nm), a semiconductor laser (wavelength: 405 nm), and the like can be used, and a high-pressure mercury lamp is preferred. These wavelengths may fall within a range of  $\pm 1\%$ . Heating can also be performed after the exposure (post exposure bake, PEB), if necessary. The temperature of the PEB is preferably 80 to 150°C, more preferably 100 to 140°C, and the heating time is 0.3 to 5 minutes, preferably 0.5 to 2 minutes. [0074]

#### Step (4)

The exposed resist film is developed with the use of a developer. As a method for the development, a method conventionally for use in developing a photoresist can be used, such as a paddle development method, an immersion development method, or a swing immersion development method. As the developer, an aqueous solution is used, which contains an inorganic alkali such as sodium hydroxide, potassium hydroxide, sodium carbonate, or sodium silicate, ammonia, an organic amine such as ethylamine, propylamine, diethylamine, diethylaminoethanol, or triethylamine, a quaternary amine such as tetramethylammonium hydroxide (TMAH), or the like, and an aqueous solution of 2.38% by mass TMAH is preferred. A surfactant can also be further added to the developer. The temperature of the developer is preferably 5 to 50°C, more preferably 25 to 40°C, and the developing time is preferably 100 to 600 seconds, more preferably 200 to 480 seconds. After the development, water washing or rinsing can also be performed, if necessary. When a negative resist composition is used, the unexposed part is removed by the development to form a resist pattern composed of the exposed part.

[0075]

A processed substrate can be produced by a method further comprising the following steps:

(5) performing a processing treatment with the resist pattern as a mask.  
As an embodiment of the present invention, it is preferable to form holes and trenches that have a high aspect ratio and form a pattern such as pillars at a high aspect ratio.

5 [0076]

Step (5)

The formed resist pattern is preferably used for processing a lower layer film or a substrate (more preferably a substrate). Specifically, with the resist pattern as a mask, various substrates to serve as bases can be processed by using a dry etching method, a wet etching method, an ion implantation method, a metal plating method, or the like. It is a more preferred embodiment to perform further processing such as metal electroplating, and formation of metal lines, bumps, trenches, and other structures, with the resist pattern according to the present invention as a mask.

15 [0077]

The resist pattern formed from the composition according to the present invention shows high compatibility with a copper plating solution. By selectively electroplating with the use of a resist obtained by pattern formation, copper pillars with a diameter in the range of 20 to 500  $\mu\text{m}$  and a height in the range of 40 to 400  $\mu\text{m}$  (preferably 80 to 300  $\mu\text{m}$ ) can be formed in a favorable fashion.

20 [0078]

After forming these copper pillars by electroplating, the region with the resist formed according to the present invention can be easily peeled by using conventional conditions, for example with the use of TMAH and an organic solvent, for example, DMSO, N-methylpyrrolidone, 2-aminoethanol and analogs, or mixtures of such organic solvents, and a common peeling agent based on a surfactant. The peeling condition is, for example, 70°C for 30 to 90 minutes.

30 [0079]

Thereafter, if necessary, the substrate is further processed, preferably, a step of forming a wiring on the processed substrate is performed, thereby

allowing a device to be produced. Known methods can be applied to these types of processing. If necessary, the substrate is cut into chips, connected to a lead frame, and packaged with a resin. In the present invention, this packaged product is referred to as a device. Examples of the device include a semiconductor element, a liquid crystal display element, an organic EL display element, a plasma display element, and a solar cell element, and preferred is a semiconductor element.

[0080]

The use of the resist composition according to the present invention allows controlling the pattern shape of a resist pattern to be formed. Accordingly, the present invention provides the following method as another aspect.

A method for controlling the shape of a pillar with a high aspect ratio by forming a resist pattern with the use of the resist composition according to the present invention.

Details of the resist composition in the method mentioned above are as described above. In addition, details of the resist film, resist pattern, processed substrate, and method for producing a device are as described above.

[Examples]

[0081]

The present invention is described by way of examples as follows. It is to be noted that the embodiment of the present invention is not limited to only these examples.

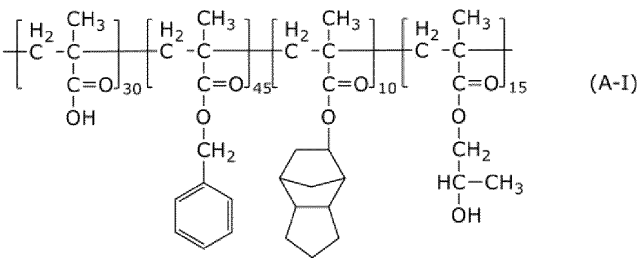
[0082]

Preparation of Composition

Compositions of Examples 1 to 3 and Comparative Examples 1 and 2 are mixed in accordance with the components in parts by mass as listed in Table 1. Each of the compositions is mixed for 2 days. These are filtered to obtain respective compositions. The kinematic viscosity of each of the compositions is measured at 25°C and is shown in Table 1. As for the kinematic viscosity, after keeping each of the compositions at 25°C, with

the use of an automatic viscosity measuring apparatus VMC-552 (RIGO CO., LTD.), the sample is sucked to start the measurement, and automatic arithmetic processing is performed by measuring the flow-down seconds to obtain the numerical value of the dynamic viscosity.

5 ·Polymer (A-I): poly[methacrylic acid-co-benzyl methacrylate-co-tricyclo(5.2.1.0/2.6)decylmethacrylate-co-2-hydroxypropyl methacrylate (MIPHOTO CPR215)  
[C20]



10 [0083]

[Table 1]

| Component                            | Name of Component     | Example 1     | Example 2     | Example 3     | Comparative Example 1 | Comparative Example 2 |
|--------------------------------------|-----------------------|---------------|---------------|---------------|-----------------------|-----------------------|
|                                      |                       | parts by mass | parts by mass | parts by mass | parts by mass         | parts by mass         |
| Polymer (A-I)                        | MIPHOTO CPR215        | 62.40         | 62.40         | 54.71         | 62.59                 | 62.40                 |
| Additive                             | TPPA                  | 6.93          | 6.93          | 6.08          | 6.96                  | 6.93                  |
| Compound represented by Formula (II) | A-DCP                 | 22.19         | 22.19         | 29.18         | 22.25                 | 22.18                 |
|                                      | SR-268                | 5.54          | 5.55          | 7.30          | 5.56                  | 5.55                  |
| Polymerization Initiator             | Irgacure819           | 2.77          | 2.77          | 2.43          | 2.78                  | 2.78                  |
| Radical Scavenger                    | Lignostab1198         | 0.04          | 0.03          | 0.03          | 0.03                  | 0.03                  |
| Surfactant                           | KF353A (25% in MMPOM) |               |               |               | 0.14                  |                       |
|                                      | KF353A (25% in PGPE)  |               |               |               |                       | 0.14                  |
|                                      | KF353A (25% in 3-MBA) | 0.14          |               |               |                       |                       |
|                                      | KF353A (25% in 3-MB)  |               | 0.14          | 0.27          |                       |                       |
| Solvent                              | MMPOM                 |               |               |               | 54.97                 |                       |
|                                      | PGME                  |               |               |               |                       | 53.61                 |
|                                      | 3-MBA                 | 76.37         |               |               |                       |                       |
|                                      | 3-MB                  |               | 60.77         | 50.11         |                       |                       |
| Boiling Point (°C)                   |                       | 172           | 161           | 161           | 171                   | 120                   |
| Kinematic Viscosity (cSt)            |                       | 6,000         | 6,000         | 5,600         | 6,000                 | 6,000                 |

[0084]

Table 2 is a list of chemicals used for the above-mentioned compositions and the suppliers of the chemicals.

15

[Table 2]

| Component         | Name                                                                                                                  | Supplier                           |
|-------------------|-----------------------------------------------------------------------------------------------------------------------|------------------------------------|
| MIPHOTO<br>CPR215 | poly(methacrylic acid-co-benzylmethacrylate-co-tricyclo(5.2.1.0/2.6)decylmethacrylate-co-2-hydroxypropylmethacrylate) | Miwon Commercial                   |
| TPPA              | $\alpha$ , $\alpha$ -bis(4-hydroxyphenyl)-4-(4-hydroxy- $\alpha$ , $\alpha$ -dimethylbenzyl)ethylbenzene              | Honshu Chemical Industry Co., Ltd. |
| A-DCP             | tricyclodecane dimethanol diacrylate                                                                                  | Shin-Nakamura Chemical Co., Ltd.   |
| SR-268            | tetraethylene glycol diacrylate                                                                                       | Arkema                             |
| Irgacure819       | bis(2,4,6-trimethylbenzoyl)phenylphosphine oxide                                                                      | BASF Japan Ltd.                    |
| Lignostab1198     | 4-hydroxy-2,2,6,6-tetramethylpiperidineoxyl                                                                           | BASF Japan Ltd.                    |
| KF353A            | polyether-modified organosiloxane                                                                                     | Shin-Etsu Chemical Co., Ltd.       |
| MMPOM             | propylene glycol dimethyl ether                                                                                       | Toho Chemical Industry Co., Ltd.   |
| PGME              | 1-methoxy-2-propanol                                                                                                  | Daicel Corporation                 |
| 3-MBA             | 3-methoxybutyl acetate                                                                                                | Tokyo Chemical Industry Co., Ltd.  |
| 3-MB              | 3-methoxy-1-butanol                                                                                                   | Sigma-Aldrich Japan                |

[0085]

## Formation of Resist Film

8-inch and 12-inch silicon wafers are each coated with each of the compositions of Examples 1 to 3 and Comparative Examples 1 and 2 at 1000 rpm/3 sec (main spin) for 21 seconds with the use of an ACS300 Gen2 coater (SUSS MicroTech Group).

Thereafter, the compositions are dried on a hot plate at 120°C for 5 minutes to obtain resist films of Examples 1 to 3 and Comparative Examples 1 and 2 that differ in film thickness.

[0086]

## Pattern Formation Evaluation

With the use of an 8-inch silicon wafer, resist films are prepared as described in "Formation of Resist Film". Each of the resist films is automatically exposed with energy of 600 to 2000 mJ/cm<sup>2</sup> with the use of an ORC PPS-8300 stepper (ORC MANUFACTURING CO., LTD.). The exposed resist film is developed with the use of a 0.26 N aqueous solution of tetramethylammonium hydroxide in an ACS300 Gen2 developer (SUSS MicroTech Group). When the condition of the developed resist film is observed with a scanning electron microscope JSM-7001F (JEOL Ltd.), the formation of a pattern is confirmed in each of the resist films.

[0087]

Evaluation of Presence or Absence of Surface Bubble

With the use of an 8-inch silicon wafer, resist films are prepared as described in “Formation of Resist Film”. The entire surface of each of the resist films is observed visually and with an optical microscope, and the average value of the numbers of recognizable bubbles is calculated and evaluated as follows. The evaluation results are shown in Table 3.

- A: The average value of the numbers of bubbles is less than 5.
- B: The average value of the numbers of bubbles is 5 or more and less than 10.
- C: The average value of the numbers of air bubbles is 10 or more.

[0088]

Evaluation of Resist Film Thickness

With the use of 8-inch and 12-inch silicon wafers, resist films are prepared as described in “Formation of Resist Film”. The film thickness of each of the resist films is measured with the use of Foothill KT-22(Foothill Instruments, LLC).

The measurement results are shown in Table 3.

[0089]

[Table 3]

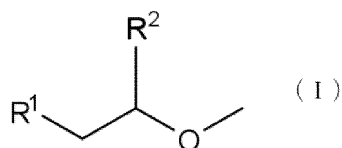
|                                       | Example 1 | Example 2 | Example 3 | Comparative Example 1 | Comparative Example 2 |
|---------------------------------------|-----------|-----------|-----------|-----------------------|-----------------------|
| Surface Bubbles on 8 inch Resist Film | B         | B         | A         | C                     | C                     |
| Film Thickness (8 inch, μm)           | 148.90    | 150.30    | 161.85    | unmeasurable          | 166.60                |
| Film Thickness (12 inch, μm)          | 113.90    | 131.40    | 139.06    | unmeasurable          | unmeasurable          |

## [CLAIMS]

## [Claim 1]

A resist composition comprising a polymer, a solvent represented by formula (I), and a compound represented by formula (II):

[C1]



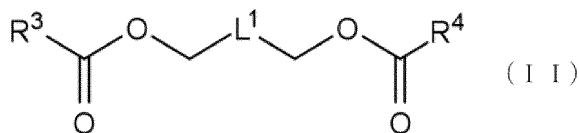
where:

R<sup>1</sup> and R<sup>2</sup> are each independently C<sub>1-15</sub> alkyl or C<sub>1-15</sub> alkoxy, preferably C<sub>1-10</sub> alkyl, more preferably C<sub>1-5</sub> alkyl;

one or more H atoms in R<sup>1</sup> may each independently be replaced with -COOH or -OH; and

one or more non-adjacent methylene (-CH<sub>2</sub>-) groups in R<sup>1</sup> may each independently be replaced with -S-, -CO-, -CO-O-, -O-CO-, -O-CO-O-, -CH=CH-, or -C≡C-;

[C2]



where:

R<sup>3</sup> and R<sup>4</sup> are each independently -CH=CH<sub>2</sub> or -CH≡CH, preferably -CH=CH<sub>2</sub>;

L<sup>1</sup> is a C<sub>1-20</sub> saturated aliphatic hydrocarbon group, preferably a C<sub>1-15</sub> saturated aliphatic hydrocarbon group, more preferably a C<sub>1-10</sub> saturated aliphatic hydrocarbon group;

one or more non-adjacent methylene (-CH<sub>2</sub>-) groups in L<sup>1</sup> may each independently be replaced with -O-, -S-, -CO-, -CO-O-, -O-CO-, -O-CO-O-, -CH=CH-, or -C≡C-.

[Claim 2]

The resist composition according to claim 1, wherein the solvent has a boiling point of 130 to 300°C, preferably 140 to 250°C, more preferably 150 to 200°C.

[Claim 3]

5       The resist composition according to claim 1 or 2, wherein the resist composition has a kinematic viscosity of 700 to 7,500 cSt, preferably 2,200 to 7,000 cSt, more preferably 3,000 to 6,500 cSt at 25°C.

[Claim 4]

10       The resist composition according to any one of claims 1 to 3, wherein the resist composition has a viscosity of 1,000 to 8,000 cP, preferably 3,000 to 7,000 cP, more preferably 4,000 to 6,500 cP at 25°C.

[Claim 5]

15       The resist composition according to any one of claims 1 to 4, wherein the content of the solvent is 30 to 95 parts by mass, preferably 40 to 90 parts by mass, more preferably 50 to 80 parts by mass, based on 100 parts by mass of all of components excluding the solvent in the resist composition.

[Claim 6]

20       The resist composition according to any one of claims 1 to 5, wherein the ratio by mass of the compound to the polymer is 0.15 to 0.85, preferably 0.20 to 0.80, more preferably 0.30 to 0.75.

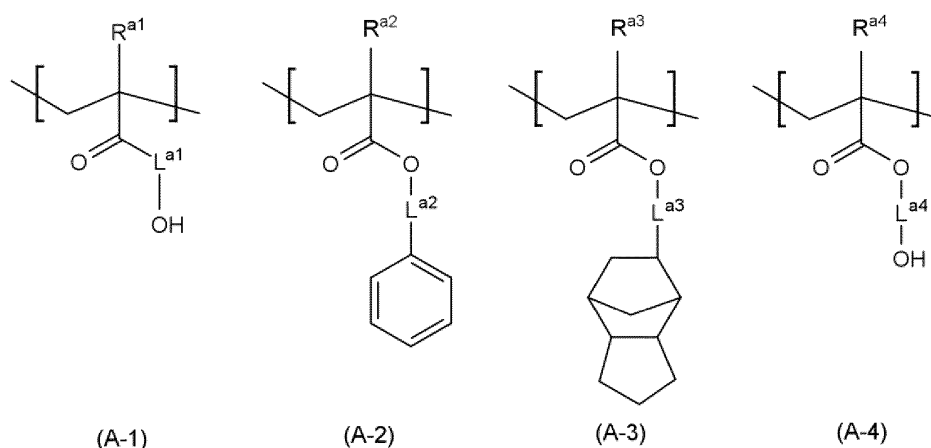
[Claim 7]

25       The resist composition according to any one of claims 1 to 6, further comprising a compound represented by formula (II) and different in structure from the compound.

[Claim 8]

The resist composition according to any one of claims 1 to 7, wherein the polymer comprises at least one of repeating units represented by formulas (A-1) to (A -4);

[C3]



where:

R<sup>a1</sup> to R<sup>a4</sup> are each independently hydrogen or C<sub>1-10</sub> alkyl, preferably C<sub>1-5</sub> alkyl, more preferably methyl; and

5 L<sup>a1</sup> to L<sup>a4</sup> are each independently a single bond or C<sub>1-10</sub> alkylene, preferably a single bond or C<sub>1-5</sub> alkylene, more preferably a single bond or C<sub>1-3</sub> alkylene.

[Claim 9]

10 The resist composition according to any one of claims 1 to 8, further comprising a polymerization initiator.

[Claim 10]

The resist composition according to any one of claims 1 to 9, wherein the resist composition is a negative resist composition.

[Claim 11]

15 A method for producing a resist film, comprising applying the resist composition according to any one of claims 1 to 10 above a substrate, and preferably heating the resist composition.

[Claim 12]

20 A resist film produced by the method according to claim 11 and having a film thickness of 100 to 300 μm, preferably 110 to 250 μm, more preferably 120 to 200 μm.

[Claim 13]

A method for producing a resist pattern, comprising:

producing a resist film by the method according to claim 11;  
exposing the resist film to light;  
preferably heating the resist film after the exposure; and  
developing the exposed resist film.

5 [Claim 14]

A method for producing a processed substrate, comprising:  
producing a resist pattern by the method according to claim 13; and  
performing a processing treatment with the resist pattern as a mask.

[Claim 15]

10 A method for producing a device, comprising the method according to  
claim 14;  
preferably, further comprising a step of forming a wiring on the  
processed substrate; or  
preferably, wherein the device is a semiconductor device.

15 [Claim 16]

Use of the resist composition according to any one of claims 1 to 10 for  
producing a resist film having a film thickness of 100  $\mu\text{m}$  or more.