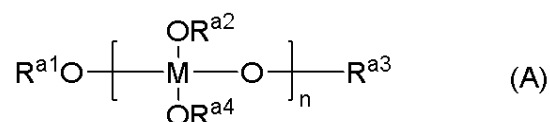
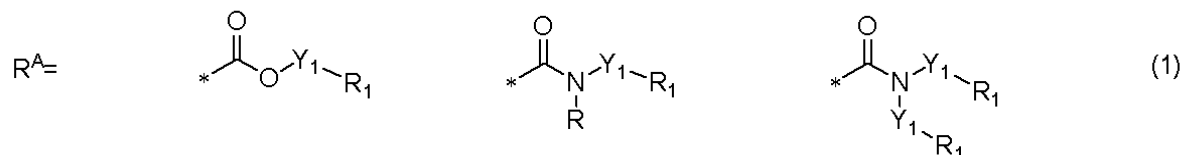


CLAIMS

[Claim 1] A compound for forming a metal-containing film to be contained in a composition for forming a metal-containing film, wherein the compound is represented by the following general formula (A),

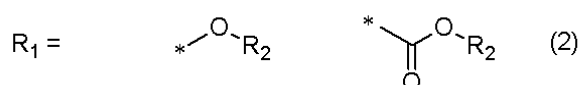


wherein M represents Ti, Zr, or Hf; $\text{R}^{\text{a}1}$, $\text{R}^{\text{a}2}$, $\text{R}^{\text{a}3}$, and $\text{R}^{\text{a}4}$ each represent a monovalent organic group having 3 to 105 carbon atoms and including an organic group R^{A} represented by one of the following general formulae (1), a silicon-containing organic group represented by the following general formula (3), or an alkyl group having 1 to 10 carbon atoms, at least one of $\text{R}^{\text{a}1}$, $\text{R}^{\text{a}2}$, $\text{R}^{\text{a}3}$, and $\text{R}^{\text{a}4}$ being a monovalent organic group having 3 to 105 carbon atoms and including an organic group R^{A} represented by one of the following general formulae (1) and at least one of $\text{R}^{\text{a}1}$, $\text{R}^{\text{a}2}$, $\text{R}^{\text{a}3}$, and $\text{R}^{\text{a}4}$ being a silicon-containing organic group represented by the following general formula (3); and "n" represents 1 to 30,

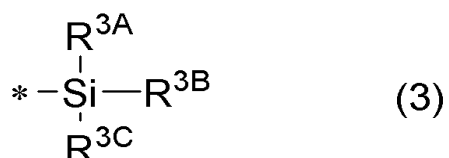


wherein Y_1 represents a divalent organic group having 1 to 20 carbon atoms; R represents a hydrogen atom, a substituted or unsubstituted saturated monovalent organic group having 1 to 20 carbon atoms or a substituted or unsubstituted unsaturated monovalent organic group having 2 to 20 carbon atoms, a substituted

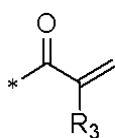
or unsubstituted aryl group having 6 to 30 carbon atoms, or a substituted or unsubstituted arylalkyl group having 7 to 31 carbon atoms; R_1 represents an organic group represented by one of the following general formulae (2), the organic group having a protecting group that is removed by an action of an acid, heat, or both to generate one or more hydroxy groups or carboxy groups; and "*" represents an attachment point,



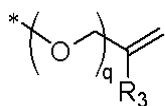
wherein R_2 represents an organic group whose protecting group is removed by an action of an acid, heat, or both; and "*" represents an attachment point to Y_1 ,



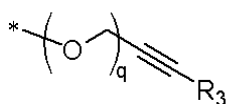
wherein R^{3A} , R^{3B} , and R^{3C} each represent any organic group selected from an organic group having 2 to 30 carbon atoms and having a crosslinking group of any structure represented by one of the following general formulae (c-1) to (c-3), a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, and an aryl group having 6 to 20 carbon atoms; and "*" represents an attachment point to an oxygen atom,



(c-1)



(c-2)

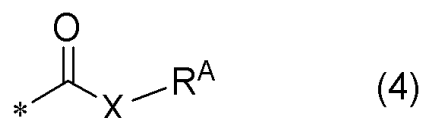


(c-3)

wherein R_3 represents a hydrogen atom or a monovalent organic group having 1 to 10 carbon atoms; "q"

represents 0 or 1; and "*" represents an attachment point.

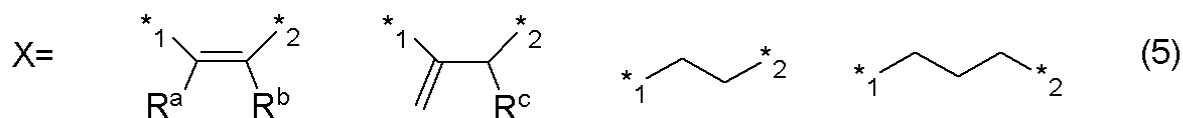
[Claim 2] The compound for forming a metal-containing film according to claim 1, wherein the monovalent organic group in the general formula (A) having 3 to 105 carbon atoms and including the organic group R^A represented by one of the general formulae (1) has a structure represented by the following general formula (4),



wherein X represents a divalent organic group having 1 to 31 carbon atoms; R^A represents one of the general formulae (1); and "*" represents an attachment point to an oxygen atom.

[Claim 3] The compound for forming a metal-containing film according to claim 2, wherein the X in the general formula (4) represents a saturated hydrocarbon group having 1 to 20 carbon atoms or an unsaturated hydrocarbon group having 2 to 20 carbon atoms.

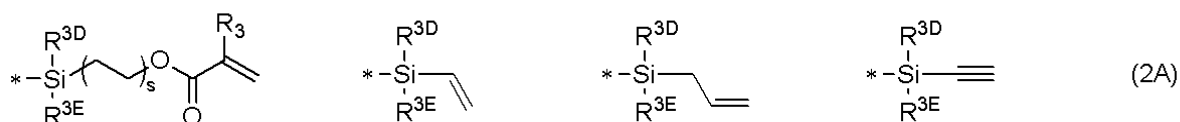
[Claim 4] The compound for forming a metal-containing film according to claim 3, wherein the X in the general formula (4) represents one of the following general formulae (5),



wherein R^a and R^b each represent a hydrogen atom or a monovalent organic group having 1 to 18 carbon atoms; R^c

represents a hydrogen atom or a monovalent organic group having 1 to 17 carbon atoms; R^a and R^b have a total of 0 to 18 carbon atoms, R^a and R^b optionally being bonded to each other to form a cyclic substituent; and “*₁” and “*₂” each represent an attachment point to a carbonyl group, “*₁” and “*₂” optionally being reversed.

[Claim 5] The compound for forming a metal-containing film according to any one of claims 1 to 4, wherein the silicon-containing organic group has a structure represented by one of the following general formulae (2A),



wherein R^{3D} and R^{3E} each represent an organic group selected from a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms and an aryl group having 6 to 20 carbon atoms; R₃ is as defined above; “s” represents 1 to 10; and “*” represents an attachment point to an oxygen atom.

[Claim 6] A composition for forming a metal-containing film used in manufacturing a semiconductor, the composition comprising: (A) the compound for forming a metal-containing film according to any one of claims 1 to 5; and (B) an organic solvent.

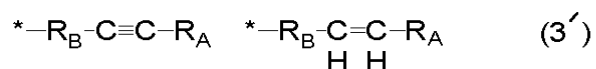
[Claim 7] The composition for forming a metal-containing film according to claim 6, further comprising one or more of (C) a crosslinking agent, (E) a surfactant, and (F) an acid generator.

[Claim 8] The composition for forming a metal-containing film according to claim 6 or 7, wherein the organic solvent (B) contains, as (B1) a high-boiling-point solvent, one or more kinds of organic solvent having a boiling point of 180°C or higher.

[Claim 9] The composition for forming a metal-containing film according to any one of claims 6 to 8, further comprising (G) metal oxide nanoparticles having an average primary particle size of 100 nm or less.

[Claim 10] The composition for forming a metal-containing film according to claim 9, wherein the metal oxide nanoparticles (G) are selected from the group consisting of zirconium oxide nanoparticles, hafnium oxide nanoparticles, titanium oxide nanoparticles, tin oxide nanoparticles, and tungsten oxide nanoparticles.

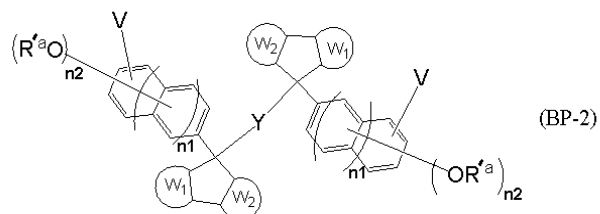
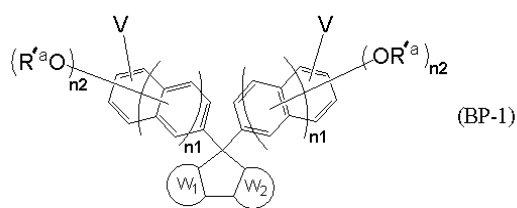
[Claim 11] The composition for forming a metal-containing film according to any one of claims 6 to 10, further comprising (BP) a flowability accelerator having any organic group represented by the following general formulae (3') and an aromatic ring,



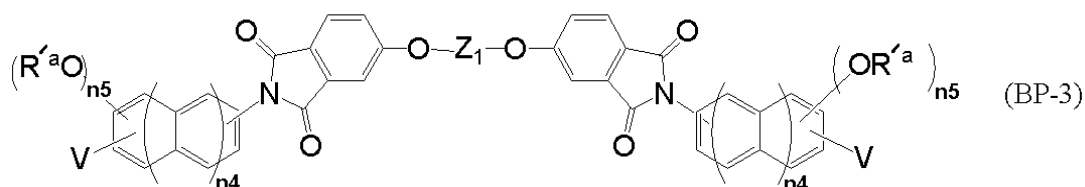
wherein "*" represents an attachment point to an oxygen atom; R_B represents a divalent organic group having 1 to 10 carbon atoms; and R_A represents a hydrogen atom or a monovalent organic group having 1 to 10 carbon atoms.

[Claim 12] The composition for forming a metal-containing film according to claim 11, wherein the flowability accelerator (BP) has at least one

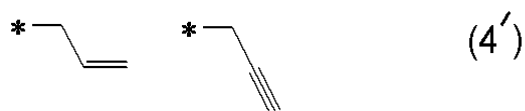
constitutional unit represented by the following general formulae (BP-1), (BP-2), (BP-3), (BP-4), and (BP-5),



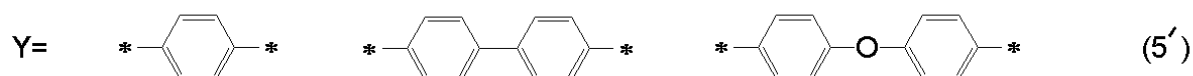
wherein W_1 and W_2 each independently represent a benzene ring or a naphthalene ring, part of hydrogen atoms in the benzene ring and the naphthalene ring optionally being substituted with a hydrocarbon group having 1 to 6 carbon atoms; each R'^a independently represents either group represented by the following formulae (4'); Y represents any group represented by the following formulae (5'); each " n_1 " independently represents 0 or 1; each " n_2 " independently represents 1 or 2; and each V independently represents a hydrogen atom or an attachment point,



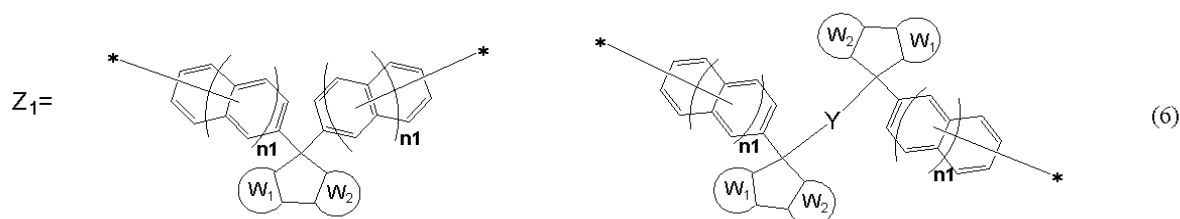
wherein Z_1 represents any group represented by the following general formulae (6); each R'^a independently represents either group represented by the following formulae (4'); each " n_4 " independently represents 0 or 1; each " n_5 " independently represents 1 or 2; and each V independently represents a hydrogen atom or an attachment point,



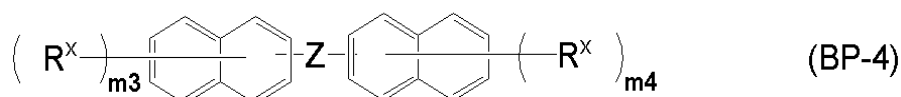
wherein "*" represents an attachment point to an oxygen atom,



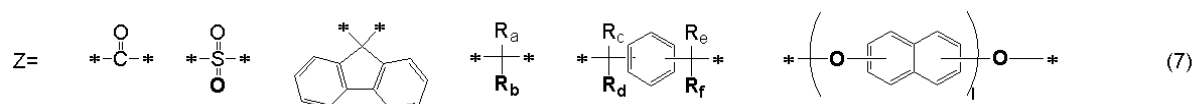
wherein "*" represents an attachment point,



wherein W_1 , W_2 , Y , and " n_1 " are as defined above; and "*" represents an attachment point,



wherein " m_3 " and " m_4 " each independently represent 1 or 2; Z represents a single bond or any structure represented by the following general formulae (7); and each R^x independently represents any structure represented by the following general formulae (8),



wherein "*" represents an attachment point; " l " represents an integer of 0 to 3; R_a to R_f each independently represent a hydrogen atom, an alkyl group having 1 to 10 carbon atoms and optionally having a substituent fluorine atom, a phenyl group, or a phenylethyl group, R_a and R_b optionally being bonded to each other to form a cyclic compound,



(9),



less; and "n'₅" represents 0 to 2,



carbon atoms; R'^a represents either group represented by

the formulae (4'); "p" represents an integer of 0 to 5 and "q₁" represents an integer of 1 to 6, provided that p+q₁ is an integer of 1 or more and 6 or less; and "q₂" represents 0 or 1.

[Claim 13] A patterning process for forming a pattern in a substrate to be processed, comprising the steps of:

(I-1) applying the composition for forming a metal-containing film according to any one of claims 6 to 12 onto a substrate to be processed, followed by heating to form a metal-containing film;

(I-2) forming a resist upper layer film on the metal-containing film by using a photoresist material;

(I-3) subjecting the resist upper layer film to pattern exposure and then development with a developer to form a pattern in the resist upper layer film;

(I-4) transferring the pattern to the metal-containing film by dry etching while using the resist upper layer film having the formed pattern as a mask; and

(I-5) processing the substrate to be processed while using the metal-containing film having the formed pattern as a mask to form the pattern in the substrate to be processed.

[Claim 14] A patterning process for forming a pattern in a substrate to be processed, comprising the steps of:

(II-1) applying the composition for forming a metal-containing film according to any one of claims 6 to 12 onto a substrate to be processed, followed by heating to form a metal-containing film;

(II-2) forming a silicon-containing resist middle layer film on the metal-containing film;

(II-3) forming a resist upper layer film on the silicon-containing resist middle layer film by using a photoresist material;

(II-4) subjecting the resist upper layer film to pattern exposure and then development with a developer to form a pattern in the resist upper layer film;

(II-5) transferring the pattern to the silicon-containing resist middle layer film by dry etching while using the resist upper layer film having the formed pattern as a mask;

(II-6) transferring the pattern to the metal-containing film by dry etching while using the silicon-containing resist middle layer film having the transferred pattern as a mask; and

(II-7) processing the substrate to be processed while using the metal-containing film having the formed pattern as a mask to form the pattern in the substrate to be processed.

[Claim 15] A patterning process for forming a pattern in a substrate to be processed, comprising the steps of:

(III-1) applying the composition for forming a metal-containing film according to any one of claims 6 to 12 onto a substrate to be processed, followed by heating to form a metal-containing film;

(III-2) forming an inorganic hard mask middle layer film selected from a silicon oxide film, a silicon nitride film, and a silicon oxynitride film on the metal-containing film;

(III-3) forming an organic thin film on the inorganic hard mask middle layer film;

(III-4) forming a resist upper layer film on the organic thin film by using a photoresist material;

(III-5) subjecting the resist upper layer film to pattern exposure and then development with a developer to form a pattern in the resist upper layer film;

(III-6) transferring the pattern to the organic thin film and the inorganic hard mask middle layer film by dry etching while using the resist upper layer film having the formed pattern as a mask;

(III-7) transferring the pattern to the metal-containing film by dry etching while using the inorganic hard mask middle layer film having the transferred pattern as a mask; and

(III-8) processing the substrate to be processed while using the metal-containing film having the formed pattern as a mask to form the pattern in the substrate to be processed.

[Claim 16] The patterning process according to claim 15, wherein the inorganic hard mask middle layer film is formed by a CVD method or an ALD method.

[Claim 17] A patterning process for forming a pattern in a substrate to be processed, comprising the steps of:

(IV-1) applying the composition for forming a metal-containing film according to any one of claims 6 to 12 onto a substrate to be processed, followed by heating to form a metal-containing film;

(IV-2) forming a resist underlayer film on the metal-containing film;

(IV-3) forming a silicon-containing resist middle layer film or a combination of an inorganic hard mask middle layer film selected from a silicon oxide film, a silicon nitride film, and a silicon oxynitride film and an organic thin film on the resist underlayer film;

(IV-4) forming a resist upper layer film on the silicon-containing resist middle layer film or the organic thin film by using a photoresist material;

(IV-5) subjecting the resist upper layer film to pattern exposure and then development with a developer to form a pattern in the resist upper layer film;

(IV-6) transferring the pattern to the silicon-containing resist middle layer film or the organic thin film and the inorganic hard mask middle layer film by dry etching while using the resist upper layer film having the formed pattern as a mask;

(IV-7) transferring the pattern to the resist underlayer film by dry etching while using the silicon-containing resist middle layer film or the inorganic hard mask middle layer film having the transferred pattern as a mask;

(IV-8) transferring the pattern to the metal-containing film by dry etching while using the resist underlayer film having the transferred pattern as a mask; and

(IV-9) processing the substrate to be processed while using the metal-containing film having the formed pattern as a mask to form the pattern in the substrate to be processed.

[Claim 18] A tone-reversal patterning process for forming a pattern in a substrate to be processed, comprising the steps of:

(V-1) forming a resist underlayer film on a substrate to be processed;

(V-2) forming a resist middle layer film or a combination of an inorganic hard mask middle layer film selected from a silicon oxide film, a silicon nitride

film, and a silicon oxynitride film and an organic thin film on the resist underlayer film;

(V-3) forming a resist upper layer film on the resist middle layer film or the combination of the inorganic hard mask middle layer film and the organic thin film by using a photoresist material;

(V-4) subjecting the resist upper layer film to pattern exposure and then development with a developer to form a pattern in the resist upper layer film;

(V-5) transferring the pattern to the resist middle layer film or the organic thin film and the inorganic hard mask middle layer film by dry etching while using the resist upper layer film having the formed pattern as a mask;

(V-6) transferring the pattern to the resist underlayer film by dry etching while using the resist middle layer film or the inorganic hard mask middle layer film having the transferred pattern as a mask;

(V-7) applying the composition for forming a metal-containing film according to any one of claims 6 to 12 onto the resist underlayer film having the formed pattern, followed by heating to cover the resist underlayer film with a metal-containing film, thereby filling a space between the resist underlayer film patterns with the metal-containing film;

(V-8) etching back the metal-containing film covering the resist underlayer film having the formed pattern by a chemical stripper or dry etching to expose an upper surface of the resist underlayer film having the formed pattern;

(V-9) removing the resist middle layer film or the inorganic hard mask middle layer film remaining on the upper surface of the resist underlayer film by dry

etching;

(V-10) removing the resist underlayer film having the formed pattern with its surface exposed by dry etching to form a reverse pattern of an original pattern on the metal-containing film; and

(V-11) processing the substrate to be processed while using the metal-containing film having the formed reverse pattern as a mask to form the reverse pattern in the substrate to be processed.