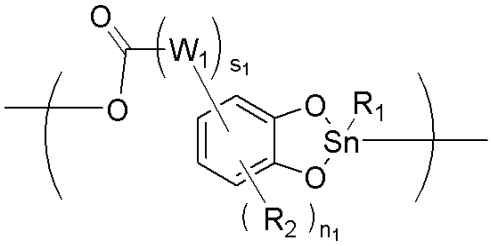
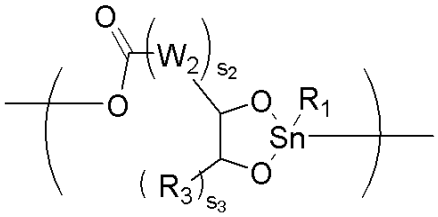
CLAIMS

[Claim 1]

A compound for forming a metal-containing film, being a polymer containing one or both of repeating units represented by the following general formula (P-1) or (P-2),



(P-1)



(P-2)

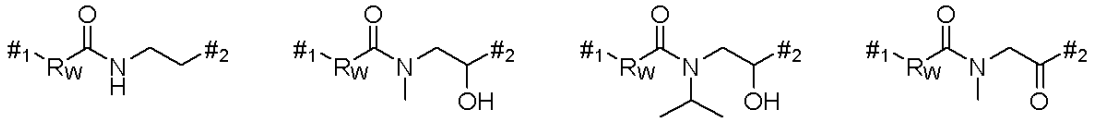
wherein R_1 represents a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted cycloalkyl group having 3 to 20 carbon atoms, a substituted or unsubstituted aliphatic unsaturated hydrocarbon group having 2 to 20 carbon atoms and having one or more double bonds or triple bonds, 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; W_1 represents a linear, branched, or cyclic, saturated or unsaturated hydrocarbon group having 1 to 40 carbon atoms, the hydrocarbon group optionally containing any heteroatom of an oxygen atom, a nitrogen atom, or a sulfur atom, and optionally forming an ether bond, a carbonyl group, an ester group, or an amide group, and optionally forming a heterocyclic structure via the heteroatom; R_2 represents a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted cycloalkyl group having 3 to 20 carbon atoms, a substituted or unsubstituted aliphatic

unsaturated hydrocarbon group having 2 to 20 carbon atoms and having one or more double bonds or triple bonds, a hydroxy group, an amino group, or a halogen atom; “s_1” represents an integer of 0 or 1; n_1 represents an integer of 0 or 1; a plurality of different kinds of the R_1, W_1, R_2, “s_1”, and “n_1” in the repeating units are optionally contained; W_2 represents a linear, branched, or cyclic, saturated or unsaturated hydrocarbon group having 1 to 40 carbon atoms, the hydrocarbon group optionally containing any heteroatom of an oxygen atom, a nitrogen atom, or a sulfur atom, and optionally forming an ether bond, a carbonyl group, an ester group, or an amide group, and optionally forming a heterocyclic structure via the heteroatom; “s_2” represents an integer of 0 or 1; “s_3” represents 1 or 2, when “s_3” is 1, R_3 being a hydrogen atom or a hydrocarbon group having 1 to 10 carbon atoms and having a hydroxy group, and when “s_3” is 2, the R_3 being an oxygen atom forming a carbonyl group together with the carbon atom bonded thereto; and the W_2 and the R_3 are optionally bonded to each other to form a cyclic structure; and a plurality of different kinds of the W_2, “s_2”, “s_3”, and R_3 in the repeating units are optionally contained.

[Claim 2]

The compound for forming a metal-containing film according to claim 1, the compound being the polymer containing the repeating unit represented by the general formula (P-1), wherein the W_1 in the general formula (P-1) is: a linear, branched, or cyclic, saturated or unsaturated hydrocarbon group having 1 to 10 carbon atoms and optionally containing a hydroxy group or an amino group, the hydrocarbon group optionally containing

an oxygen atom, a nitrogen atom, or a sulfur atom and optionally forming an ether bond, a carbonyl group, or an ester group; or any one of groups represented by the following general formulae (W_1-1) to (W_1-4),

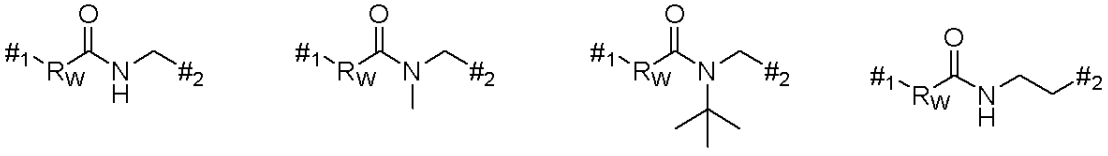


(W_1-1) (W_1-2) (W_1-3) (W_1-4)

wherein R_W represents a divalent organic group having 1 to 23 carbon atoms, "$\#_1$" represents an attachment point to the ester group, and "$\#_2$" represents an attachment point to the benzene ring.

[Claim 3]

The compound for forming a metal-containing film according to claim 1 or claim 2, the compound being the polymer containing the repeating unit represented by the general formula (P-2), wherein the W_2 in the general formula (P-2) is: a linear, branched, or cyclic, saturated or unsaturated hydrocarbon group having 1 to 10 carbon atoms and optionally containing a hydroxy group or an amino group, or a cyclic hydrocarbon group bonded to the R_3, the hydrocarbon group optionally containing an oxygen atom, a nitrogen atom, or a sulfur atom and optionally forming an ether bond, a carbonyl group, or an ester group; or any one of groups represented by the following general formulae (W_2-1) to (W_2-4),



(W_2-1) (W_2-2) (W_2-3) (W_2-4)

wherein R_W represents a divalent organic group having 1 to 23 carbon atoms; and "$\#_1$" represents an attachment

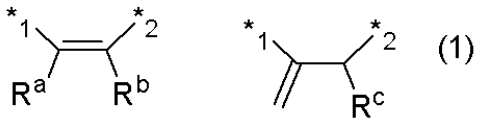
point to the ester group, and "#$_2$" represents an attachment point to the carbon atom.

[Claim 4]

The compound for forming a metal-containing film according to claim 2, wherein the R_W in the general formulae (W_1-1) to (W_1-4) is an unsaturated hydrocarbon group having 2 to 23 carbon atoms.

[Claim 5]

The compound for forming a metal-containing film according to claim 4, wherein the R_W is a group represented by any one of the following general formulae (1),



(1)

wherein R^a, R^b, and R^C each represent a hydrogen atom or a monovalent organic group having 1 to 20 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 the carbonyl group, "*1" and "*2" optionally being reversed.

[Claim 6]

The compound for forming a metal-containing film according to claim 3, wherein the R_W in the general formulae (W_2-1) to (W_2-4) is an unsaturated hydrocarbon group having 2 to 23 carbon atoms.

[Claim 7]

The compound for forming a metal-containing film according to claim 6, wherein the R_W is a group

represented by one of the following general formulae (1),

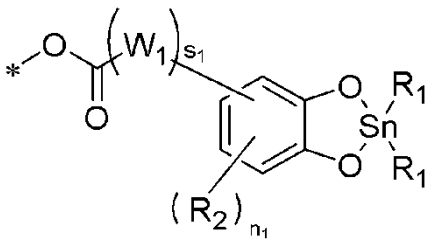


(1)

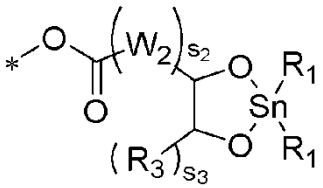
wherein R^a, R^b, and R^c each represent a hydrogen atom or a monovalent organic group having 1 to 20 carbon atoms, R^a and R^b optionally being bonded to each other to form a cyclic substituent; and "*1" and "*2" each represent an attachment point to the carbonyl group, "*1" and "*2" optionally being reversed.

[Claim 8]

The compound for forming a metal-containing film according to any one of claims 1 to 7, wherein the polymer having the repeating unit of the general formula (P-1) has a terminal structure represented by the following general formula (T-1) or the polymer having the repeating unit of the general formula (P-2) has a terminal structure represented by the following general formula (T-2),



(T-1)



(T-2)

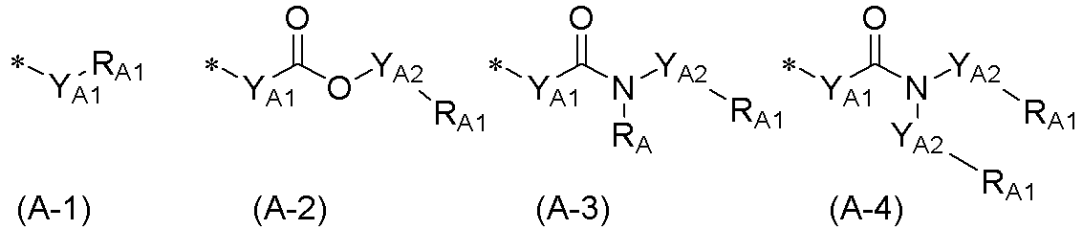
wherein R_1, R_2, R_3, W_1, W_2, "s_1", "n_1", "s_2", and "s_3" are identical to those in the general formulae (P-1) and (P-2) and "*" represents an attachment point to a terminal of the polymer.

[Claim 9]

The compound for forming a metal-containing film according to any one of claims 1 to 7, wherein the polymer having the repeating unit of the general formula (P-1) or (P-2) has a terminal structure represented by *-OC(=O)R, R representing a monovalent organic group and "*" representing an attachment point to the Sn atom in the polymer.

[Claim 10]

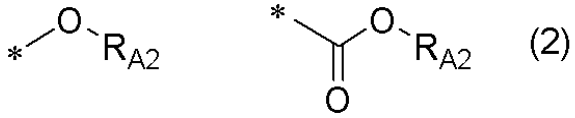
The compound for forming a metal-containing film according to claim 9, wherein the R in the terminal structure *-OC(=O)R is any one of groups represented by the following general formulae (A-1) to (A-4), the following general formula (3), and the following general formula (4),



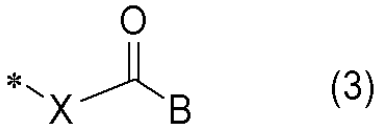
(A-1) (A-2) (A-3) (A-4)

wherein Y_{A1} and Y_{A2} are each identical to or different from each other and represent a substituted or unsubstituted saturated divalent organic group having 1 to 23 carbon atoms, a substituted or unsubstituted unsaturated divalent organic group having 2 to 23 carbon atoms, a substituted or unsubstituted arylene group having 6 to 30 carbon atoms, or a substituted or unsubstituted arylalkylene group having 7 to 31 carbon atoms; R_A represents a hydrogen atom, a substituted or unsubstituted saturated monovalent organic group having 1 to 20 carbon atoms, 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_{A1} represents an organic group whose protecting group is to be removed by an action of an acid, heat, or both to generate one or more hydroxy groups or carboxy groups, R_{A1} being represented by one of the following general formulae (2); and "*" represents an attachment point to the carbonyl group,

R_{A1} =  (2)

wherein R_{A2} represents an organic group whose protecting group is to be removed by an action of an acid, heat, or both; and "*" represents an attachment point to Y_{A1} or Y_{A2},

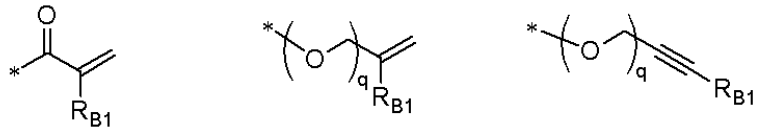
 (3)

wherein X represents a divalent organic group having 1 to 31 carbon atoms; B represents the following general formula (B); and "*" represents an attachment point to the carbonyl group,

B= $*-Y_B-R_B$ (B)

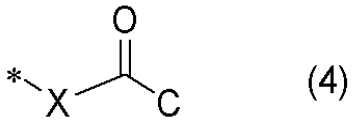
wherein Y_B represents a substituted or unsubstituted saturated divalent organic group having 1 to 20 carbon atoms, a substituted or unsubstituted unsaturated divalent organic group having 2 to 20 carbon atoms, a substituted or unsubstituted divalent arylene group having 6 to 30 carbon atoms, or a substituted or unsubstituted divalent arylalkylene group having 7 to 31 carbon atoms; R_B represents a hydroxy group or any one of

structures represented by the following general formulae (B-1) to (B-3),



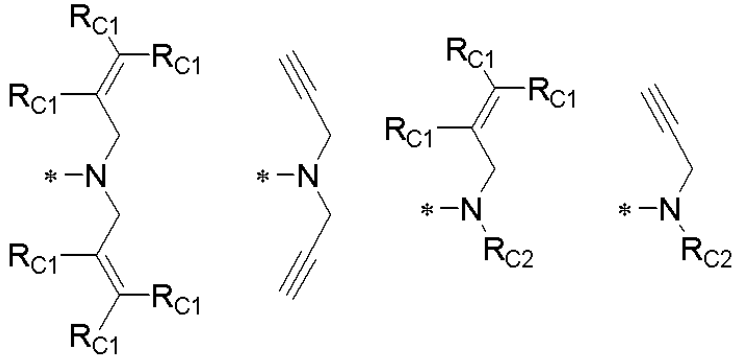
(B-1) (B-2) (B-3)

wherein R_{B1} 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 to Y_B,



(4)

wherein X represents a divalent organic group having 1 to 31 carbon atoms; C represents any one of groups represented by the following general formulae (C-1) to (C-4); and "*" represents an attachment point to the carbonyl group, and



(C-1) (C-2) (C-3) (C-4)

wherein R_{C1}s each represent a hydrogen atom or a methyl group and are identical to or different from each other in a single formula; R_{C2} represents a hydrogen atom, a substituted or unsubstituted, saturated or unsaturated monovalent organic group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms, a substituted or unsubstituted arylalkyl

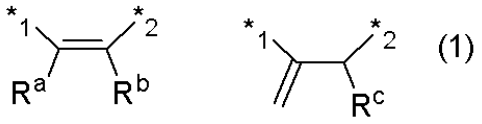
group having 7 to 31 carbon atoms; and “*” represents an attachment point to the carbonyl group.

[Claim 11]

The compound for forming a metal-containing film according to claim 10, wherein the Y_{A1} in the general formulae (A-1) to (A-4), the X in the general formula (3), or the X in the general formula (4) is an unsaturated hydrocarbon group having 2 to 23 carbon atoms.

[Claim 12]

The compound for forming a metal-containing film according to claim 10, wherein the Y_{A1} in the general formulae (A-1) to (A-4), the X in the general formula (3), or the X in the general formula (4) is a group represented by one of the following general formulae (1),



(1)

wherein R^a, R^b, and R^C each represent a hydrogen atom or a monovalent organic group having 1 to 20 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 the carbonyl group or $-R_{A1}$ in the general formula (A-1), “*1” and “*2” optionally being reversed.

[Claim 13]

A composition for forming a metal-containing film, the composition functioning as a resist underlayer film material 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 12; and (b) an organic solvent.

[Claim 14]

The composition for forming a metal-containing film according to claim 13, wherein the composition is usable for a resist underlayer film used in a multilayer resist method, the composition further comprising one or more of (c) a crosslinking agent, (d) a surfactant, (e) a flowability accelerator, and (f) an acid generator.

[Claim 15]

The composition for forming a metal-containing film according to claim 13 or claim 14, wherein the organic solvent (b) is a mixture of one or more kinds of organic solvent having a boiling point of lower than 180°C and one or more kinds of organic solvent having a boiling point of 180°C or higher.

[Claim 16]

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 13 to 15 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 17]

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 13 to 15 onto a substrate to be processed, followed by heating to form a metal-containing film;

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

(II-3) forming a resist upper layer film on the 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 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 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 18]

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 13 to 15 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 19]

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

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

(IV-2) applying the composition for forming a metal-containing film according to any one of claims 13 to 15 onto the resist underlayer film, followed by heating to form a metal-containing film;

(IV-3) forming a resist upper layer film on the metal-containing film by using a photoresist material or forming an organic adhesive film on the metal-containing film by spin-coating and forming a resist upper layer film on the organic adhesive film by using a photoresist material;

(IV-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;

(IV-5) transferring the pattern to the metal-containing film or the organic adhesive film and the metal-containing film by dry etching while using the resist upper layer film having the formed pattern as a mask;

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

(IV-7) processing the substrate to be processed while using the resist underlayer film having the formed pattern as a mask to form the pattern in the substrate to be processed.

[Claim 20]

A 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 organic thin film and an inorganic hard mask middle layer film selected from a silicon oxide film, a silicon nitride film, and a silicon oxynitride 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 organic thin film and the inorganic hard mask middle layer 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 13 to 15 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, by dry etching, the resist underlayer film having the formed pattern with an exposed surface to form a reverse pattern of an original pattern in 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.

[Claim 21]

The patterning process according to claim 18, wherein the inorganic hard mask middle layer film is formed by a CVD method or an ALD method.

[Claim 22]

The patterning process according to claim 20, wherein the inorganic hard mask middle layer film is formed by a CVD method or an ALD method.