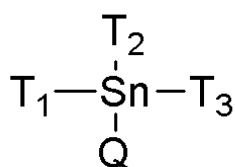


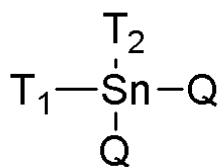
CLAIMS

[Claim 1]

A composition for forming a metal-containing film, the composition functioning as a resist underlayer film material and/or a resist material used in manufacturing a semiconductor, the composition comprising: (A) a compound for forming a metal-containing film which is represented by the following general formula (M-1) or (M-2); and (B) an organic solvent,

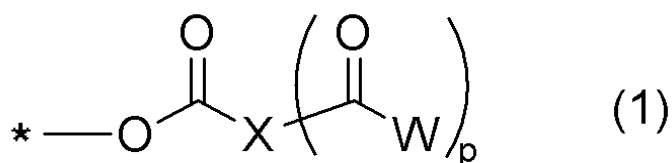


(M-1)

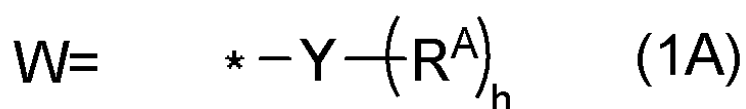


(M-2)

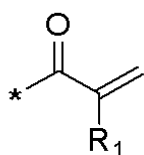
wherein T₁, T₂, and T₃ represent the following general formula (1) and are identical to or different from one another; and Q represents a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted cycloalkyl group having 3 to 20 carbon atoms, a substituted or unsubstituted aliphatic unsaturated organic 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, a substituted or unsubstituted arylalkyl group having 7 to 31 carbon atoms, or a combination of these groups,



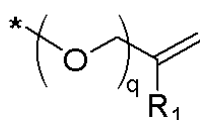
wherein X represents a saturated divalent organic group having 1 to 20 carbon atoms, an unsaturated divalent organic group having 2 to 20 carbon atoms, a saturated trivalent organic group having 1 to 20 carbon atoms, or an unsaturated trivalent organic group having 2 to 20 carbon atoms; W represents the following general formula (1A); "p" represents 1 or 2; and "*" represents an attachment point to an Sn atom,



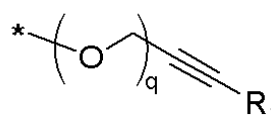
wherein Y represents a saturated divalent organic group having 1 to 20 carbon atoms and optionally being substituted with a heteroatom or an unsaturated divalent organic group having 2 to 20 carbon atoms and optionally being substituted with a heteroatom; R^A represents a hydroxy group or a structure represented by one of the following general formulae (a-1) to (a-3); "h" represents 1 to 6; and "*" represents an attachment point,



(a-1)



(a-2)



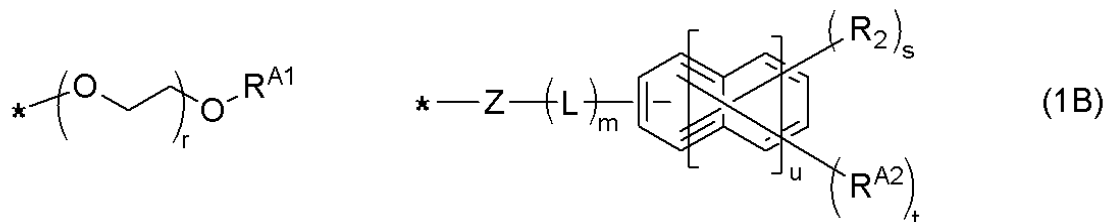
(a-3)

wherein R_1 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.

[Claim 2]

The composition for forming a metal-containing

film according to claim 1, wherein the W in the general formula (1) has a structure represented by the following general formula (1B),



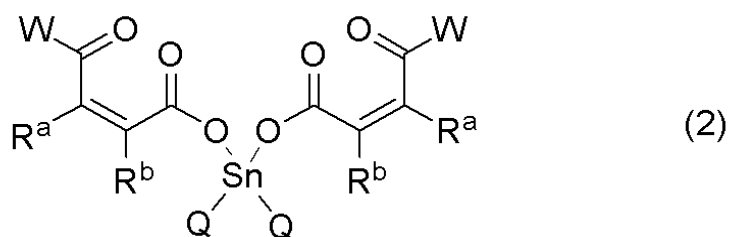
wherein R^{A1} represents a structure represented by the general formula (a-1); R^{A2} represents a hydroxy group or one of the structures represented by the general formulae (a-2) and (a-3); Z represents an oxygen atom or a secondary amine; L represents a divalent hydrocarbon group having 1 to 10 carbon atoms; R_2 represents a saturated divalent organic group having 1 to 20 carbon atoms or an unsaturated divalent organic group having 2 to 20 carbon atoms; "t" represents 1 to 6; "s" represents 0 to 5; t+s is 1 or more and 6 or less; "r" represents 1 to 10; "u" represents 0 or 1; "m" represents 0 or 1; and "*" represents an attachment point.

[Claim 3]

The composition for forming a metal-containing film according to claim 1 or 2, wherein the X in the general formula (1) represents an unsaturated hydrocarbon having 2 to 20 carbon atoms.

[Claim 4]

The composition for forming a metal-containing film according to any one of claims 1 to 3, wherein the compound for forming a metal-containing film is represented by the following general formula (2),



wherein R^a and R^b 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 together with carbon atoms bonded thereto; and Q and W are as defined above.

[Claim 5]

The composition for forming a metal-containing film according to any one of claims 1 to 4, wherein the compound for forming a metal-containing film satisfies $1.00 \leq M_w/M_n \leq 1.30$, where M_w is a weight-average molecular weight and M_n is a number-average molecular weight measured by gel permeation chromatography in terms of polystyrene.

[Claim 6]

The composition for forming a metal-containing film according to any one of claims 1 to 5, wherein the composition for forming a metal-containing film is usable as a resist underlayer film used in a multilayer resist method, the composition further comprising one or more of (C) a crosslinking agent, (D) a high-boiling-point solvent, (E) a surfactant, and (F) a flowability accelerator which is mixed with the compound for forming a metal-containing film and serves to improve the film-formability by spin-coating and the filling property for a stepped substrate,

wherein the high-boiling-point solvent (D) is one or more kinds of organic solvent having a boiling point of 180°C or higher.

[Claim 7]

The composition for forming a metal-containing film according to any one of claims 1 to 6, further comprising (G) metal oxide nanoparticles having an average primary particle size of 100 nm or less.

[Claim 8]

The composition for forming a metal-containing film according to claim 7, 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 9]

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 1 to 8 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 10]

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 1 to 8 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 11]

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 1 to 8 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 12]

The patterning process according to claim 11,

wherein the inorganic hard mask middle layer film is formed by a CVD method or an ALD method.

[Claim 13]

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 1 to 8 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;

(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 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 14]

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 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 1 to 8 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.

[Claim 15]

A patterning process comprising the steps of:
applying the composition for forming a metal-containing film according to any one of claims 1 to 8 onto a substrate, followed by heating to form a resist film;

exposing the resist film to a high-energy beam;
and

developing the exposed resist film by using a developer.

[Claim 16]

The patterning process according to claim 15, wherein an organic solvent is used as the developer.

[Claim 17]

The patterning process according to claim 16, wherein the developer is one or more organic solvents selected from 2-octanone, 2-nonanone, 2-heptanone, 3-

heptanone, 4-heptanone, 2-hexanone, 3-hexanone, diisobutyl ketone, methylcyclohexanone, acetophenone, methylacetophenone, propyl acetate, butyl acetate, isobutyl acetate, pentyl acetate, butenyl acetate, isopentyl acetate, propyl formate, butyl formate, isobutyl formate, pentyl formate, isopentyl formate, methyl valerate, methyl pentenoate, methyl crotonate, ethyl crotonate, methyl lactate, ethyl lactate, propyl lactate, butyl lactate, isobutyl lactate, pentyl lactate, isopentyl lactate, methyl 2-hydroxyisobutyrate, ethyl 2-hydroxyisobutyrate, methyl benzoate, ethyl benzoate, phenyl acetate, benzyl acetate, methyl phenylacetate, benzyl formate, phenylethyl formate, methyl 3-phenylpropionate, benzyl propionate, ethyl phenylacetate, and 2-phenylethyl acetate.

[Claim 18]

The patterning process according to any one of claims 15 to 17, wherein an extreme ultraviolet ray having a wavelength of 3 to 15 nm is used as the high-energy beam.

[Claim 19]

The patterning process according to any one of claims 15 to 17, wherein an electron beam having an acceleration voltage of 1 to 250 kV is used as the high-energy beam.

[Claim 20]

A semiconductor photoresist material, wherein the semiconductor photoresist material is the composition for forming a metal-containing film according to any one of claims 1 to 8 further comprising (H) a photo-acid

generator.