CLAIMS

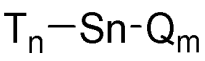
[Claim 1] A composition for forming a metal-containing film, comprising:

(A) a compound for forming a metal-containing film;

(B) an organic solvent; and

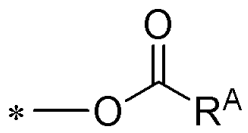
(C) an acid generator,

wherein the compound is represented by the following general formula (M),



(M)

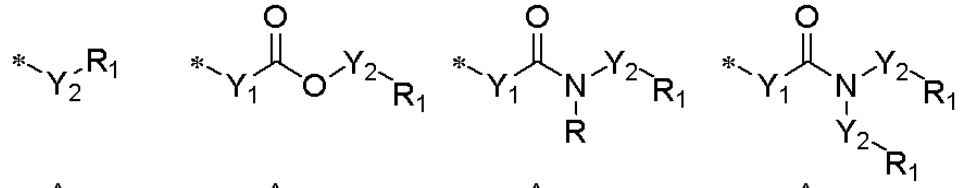
wherein “m” and “n” represent integers that satisfy relationships m + n = 4, m ≥ 1, and n ≥ 2; T’s each represent a unit represented by the following general formula (1), the T’s being identical to or different from each other and optionally being a combination of a plurality of units; and Q represents 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,



(1)

wherein R^A 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 carboxyl

groups, R^A being a group represented by one of the following general formulae (R^A—1) to (R^A—4); and "*" represents an attachment point to a Sn atom,

R^A= 

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

wherein Y_1 and Y_2 are identical to or different from each other and each represent 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 aryl group having 6 to 30 carbon atoms, or a substituted or unsubstituted arylalkyl group having 7 to 31 carbon atoms; R 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_1 represents an organic group represented by one of the following general formulae (2), wherein a protecting group of the organic group is to be removed by an action of an acid, heat, or both to generate one or more hydroxy groups or carboxyl groups; and "*" represents an attachment point to a carbonyl group,

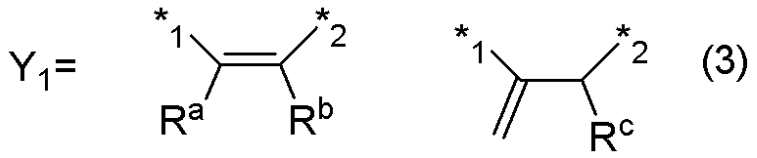
R_1 =  (2)

wherein R_2 represents an organic group whose protecting

group is to be removed by an action of an acid, heat, or both and represents a tertiary hydrocarbyl group or a group that forms an acetal structure together with an adjacent oxygen atom; and "*" represents an attachment point to Y_2.

[Claim 2] The composition for forming a metal-containing film according to claim 1, wherein the Y_1 in the general formulae (R^A—2) to (R^A—4) represents an unsaturated hydrocarbon group having 2 to 20 carbon atoms.

[Claim 3] The composition for forming a metal-containing film according to claim 1 or 2, wherein the Y_1 in the general formulae (R^A—2) to (R^A—4) represents one of the following general formulae (3),



wherein R^a and R^b each represent a hydrogen atom or a monovalent organic group having 1 to 18 carbon atoms, and R^c represents a hydrogen atom or a monovalent organic group having 1 to 17 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 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 satisfies $1.00 \leq Mw/Mn \leq 1.50$, where Mw is a weight-

average molecular weight and Mn is a number-average molecular weight measured by gel permeation chromatography in terms of polystyrene using tetrahydrofuran as an eluent.

[Claim 5] The composition for forming a metal-containing film according to any one of claims 1 to 4, further comprising one or more of:

(D) a compound or a polymer containing one or more of epoxy, oxetane, and hydroxy groups;

(E) a crosslinking agent;

(F) a surfactant; and

(G) a flowability accelerator, which is mixed with the compound for forming a metal-containing film and serves to improve a film-formability by spin-coating and a filling property for a stepped substrate.

[Claim 6] The composition for forming a metal-containing film according to any one of claims 1 to 5, wherein the organic solvent (B) contains (B1) a high-boiling-point solvent, the high-boiling-point solvent (B1) being one or more kinds of organic solvent having a boiling point of 180°C or higher.

[Claim 7] 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 claim 1 to 6 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 8] 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 claim 1 to 6 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 9] 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 6 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 the group consisting of 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 10] The patterning process according to claim 9, wherein the inorganic hard mask middle layer film is formed by a CVD method or an ALD method.

[Claim 11] 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 6 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 organic adhesive film and the metal-containing film or 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 12] 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 organic thin film of an inorganic hard mask middle layer film selected from the group consisting of 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 having the transferred pattern 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 claim 1 to 6 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.