difficult to construct a rational production process, using only conventional organic films and silicon-containing films. Therefore, a material having an etching selectivity for both film components of an organic film and a silicon-containing film is needed, in order to construct a more rational production process of a semiconductor device.

Further, resist films may be required to have a heat resistance (such as a resistance to a heat treatment, which may be carried out after forming the resist films).

Note that, the etching selectivity and the heat resistance required for resist films, as described above, are also required for films other than resist films (such as, for example, embedded dielectric films (shallow trench isolation films (STI films), pre-metal dielectric films (PMD films), inter-wiring layer dielectric films (IMD films, ILD films, etc.) and the like), from the viewpoint of realizing the formation of fine patterns.

[0009] Embodiments of the present disclosure provide: a composition for forming a metal-containing film, which composition allows for obtaining a metal-containing film having an excellent etching selectivity as well as an excellent heat resistance; and a method of producing the same.

Embodiments of the present disclosure provide: a semiconductor device using a composition for forming a metal-containing film, which composition allows for obtaining a metal-containing film having an excellent etching selectivity as well as an excellent heat resistance; and a method of producing the same.

Solution to Problem

[0010] Means for solving the above problems include the following aspects and embodiments.

According to a first aspect of the present disclosure, there is provided a composition for forming a metal-containing film, the composition including:

a compound (a1) containing a cationic functional group containing at least one of a primary nitrogen atom or a secondary nitrogen atom; and

a compound (B) which is at least one selected from the group consisting of:

a compound (b1) containing a carboxy group and a germanium atom or a tin atom, and

an ester of the compound (b1);

wherein the compound (a1) is at least one selected from the group consisting of:

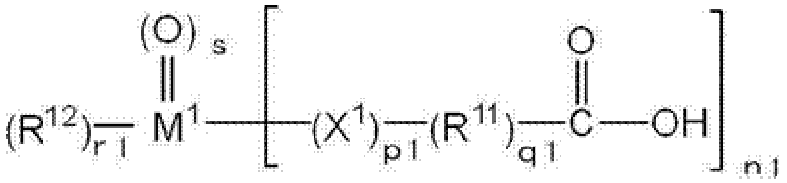
an aliphatic amine (A-1) having a weight average molecular weight of from 10,000 to 200,000,

a compound (A-2) containing a siloxane bond (Si-O bond) and an amino group, and having a weight average molecular weight of from 130 to 50,000, and

an amine (A-3) having a ring structure and having a weight average

molecular weight of from 90 to 600; and

wherein the compound (b1) is a compound represented by the following Formula (1) or the following Formula (2), or a polymer comprising at least one of a structural unit represented by the following Formula (3) or a structural unit represented by the following Formula (4):



Formula (1)

wherein, in Formula (1),

M^1 represents a germanium atom or a tin atom;

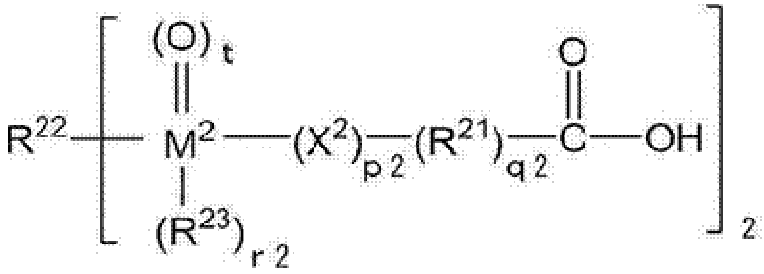
X^1 represents -S-, -S-S-, -O-, -NH-, or $-NR^{13}$-, R^{13} representing an alkyl group having from 1 to 10 carbon atoms;

R^{11} represents an optionally substituted alkylene group having from 1 to 10 carbon atoms;

R^{12} represents a hydrogen atom, an alkyl group having from 1 to 5 carbon atoms, a hydroxy group, an alkoxy group having from 1 to 5 carbon atoms, or a halogen atom;

p1 represents 0 or 1, and q1 represents 1; and

n1 represents an integer of 1 or more, r1 represents an integer of 0 or more, and s represents an integer of 0 or more, a sum of n1 + r1 + 2s being a valence of M^1



Formula (2)

wherein, in Formula (2),

M^2 represents a germanium atom or a tin atom;

X^2 represents -S-, -S-S-, -O-, -NH-, or $-NR^{24}$-, R^{24} representing an alkyl group having from 1 to 10 carbon atoms;

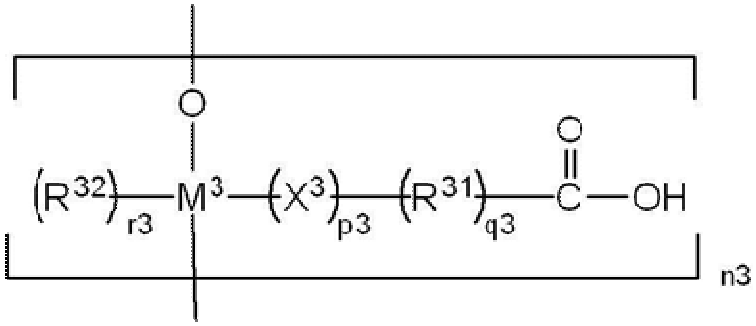
R^{21} represents an optionally substituted alkylene group having from 1 to 10 carbon atoms;

R^{22} represents a single bond, -O-, or $-NR^{25}$-, R^{25} representing an optionally substituted alkyl group having from 1 to 10 carbon atoms;

R^{23} represents a hydrogen atom, an alkyl group having from 1 to 5 carbon atoms, a hydroxy group, an alkoxy group having from 1 to 5 carbon atoms, or a halogen atom;

p2 represents 0 or 1, and q2 represents 1; and

r2 represents an integer of 0 or more, and t represents an integer of 0 or more



Formula (3)

wherein, in Formula (3),

M^3 represents a germanium atom or a tin atom;

X^3 represents -S-, -S-S-, -O-, -NH-, or $-NR^{33}-$, R^{33} representing an alkyl group having from 1 to 10 carbon atoms;

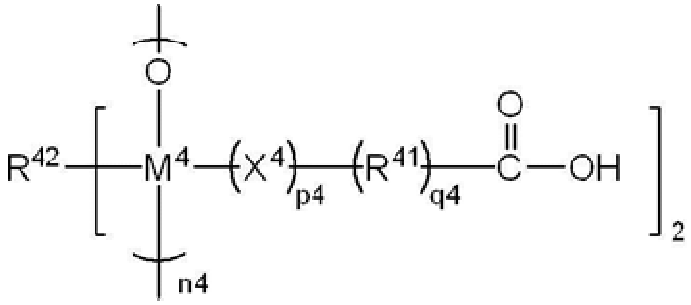
R^{31} represents an optionally substituted alkylene group having from 1 to 10 carbon atoms;

R^{32} represents a hydrogen atom, an alkyl group having from 1 to 5 carbon atoms, a hydroxy group, an alkoxy group having from 1 to 5 carbon atoms, or a halogen atom;

p3 represents 0 or 1, and q3 represents 1;

r3 represents 0 or 1; and

n3 represents an integer of 2 or more



Formula (4)

wherein, in Formula (4),

M^4 represents a germanium atom or a tin atom;

X^4 represents -S-, -S-S-, -O-, -NH-, or $-NR^{43}-$, R^{43} representing an alkyl group having from 1 to 10 carbon atoms;

R^{41} represents an optionally substituted alkylene group having from 1 to 10 carbon atoms;

R^{42} represents a single bond, -O-, or $-NR^{44}-$, R^{44} representing an optionally substituted alkyl group having from 1 to 10 carbon atoms;

p4 represents 0 or 1, and q4 represents 1; and

n4 represents an integer of 2 or more.

In an embodiment, the above composition for forming a metal-containing film, further comprises a compound (a2) which is a compound other than the compound (a1) and which contains a nitrogen atom, wherein the compound (a2) is a base (A-4) having a weight average molecular weight of from 17 to 120.

In an embodiment of the above composition for forming a metal-containing film, the compound (A) comprises the compound (a2).

[0011] In an embodiment of the above composition for forming a metal-containing film, the compound (B) has a weight average molecular weight of from 120 to 50,000.

[0020] In an embodiment of the above composition for forming a metal-containing film, in Formula (1), the sum of n1 + r1 + 2s is 4; and wherein, in Formula (2), a sum of r2 + 2t + 2 is 4.

In an embodiment, the above composition for forming a metal-containing film further comprises an additive (C) which is an acid containing a carboxy group and having a weight average molecular weight of from 46 to 195.

In an embodiment, the above composition for forming a metal-containing film further comprises a crosslinking agent (D) having a weight average molecular weight of from 200 to 600 and containing three or more -C(=O)OX groups within a molecule, each X representing a hydrogen atom or an alkyl group having from 1 to 6 carbon atoms, and from one to six of the three or more -C(=O)OX groups each being a -C(=O)OH group.

In an embodiment of the above composition for forming a metal-containing film, the composition is used for forming a metal-containing film in a multilayer resist layer comprising the metal-containing film.

In an embodiment of the above composition for forming a metal-containing film, the composition is used for forming a metal-containing film which is an embedded dielectric film in a semiconductor device comprising the metal-containing film.

[0021] According to a second aspect of the present disclosure, there is provided a method of producing the above composition for forming a metal-containing film, the method including: a mixing step of mixing at least the compound (a1) and the compound (B).

In an embodiment of the above method of producing the composition for forming a metal-containing film, the composition further comprises a compound (a2) which is a compound other than the compound (a1) and which contains a nitrogen atom, wherein the compound (a2) is a base (A-4) having a weight average molecular weight of from 17 to 120, and the mixing step is a step of mixing at least a mixture of the compound (a2) and the compound (B), with the compound (a1).

In an embodiment of the above method of producing the composition for forming a metal-containing film, the mixing step is a step of mixing at least: a mixture of an additive (C) which is an acid containing a carboxy group and having a weight average molecular weight of from 46 to 195, and the compound (a1), with the compound (B).

In an embodiment of the above method of producing the composition for forming a metal-containing film, wherein the composition further comprises a compound (a2) which is a compound other than the compound (a1) and which contains a nitrogen atom, wherein the compound (a2) is a base (A-4) having a weight average molecular weight of from 17 to 120, and the mixing step is a step of mixing at least: a mixture of the compound (a2) and the compound (B), with a mixture of an additive (C) which is an acid containing a carboxy group and having a weight average molecular weight of from 46 to 195, and the compound (a1).

[0022] According to a third aspect of the present disclosure, there is provided a semiconductor device including a metal-containing film which is an embedded dielectric film, wherein the metal-containing film includes the above composition for forming a metal-containing film.

[0023] According to a fourth aspect of the present disclosure, there is provided a method of producing a semiconductor device including a metal-containing film which is an embedded dielectric film, the method including: a step of forming the embedded dielectric film using the above composition for forming a metal-containing film.

Advantageous Effects of Invention

[0024] According to embodiments of the present disclosure, a composition for forming a metal-containing film, which composition allows for obtaining a metal-containing film having an excellent etching selectivity as well as an excellent heat resistance; and a method of producing the same are provided.

Further, according to embodiments of the present disclosure, a semiconductor device using a composition for forming a metal-containing film, which composition allows for obtaining a metal-containing film having an excellent etching selectivity as well as an excellent heat resistance; and a method of producing the same are provided.

DESCRIPTION OF EMBODIMENTS

[0025] Embodiments of the present disclosure will now be described below.

In the present specification, any numerical range indicated using an expression "from * to" represents a range in which numerical values described before and after the "to" are included in the range as a lower limit value and an upper limit value.

[0026] [Composition for Forming Metal-containing Film]

A composition for forming a metal-containing film according to the present disclosure (hereinafter, also referred to as the "composition") includes:

a compound (A) which is at least one selected from the group consisting of:

a compound (a1) containing a cationic functional group containing at least one of a primary nitrogen atom or a secondary nitrogen atom; and

a compound (a2) which is a compound other than the compound (a1) and which contains a nitrogen atom; and

a compound (B) which is at least one selected from the group consisting of:

a compound (b1) containing at least one of a germanium atom, a tin atom, a selenium atom or a zirconium atom, and a carboxy group; and

an ester of the compound (b1).

The composition for forming a metal-containing film according to the present disclosure allows for obtaining a metal-containing film having an excellent etching selectivity

CLAIMS

1. A composition for forming a metal-containing film, the composition comprising:

a compound (a1) containing a cationic functional group containing at least one of a primary nitrogen atom or a secondary nitrogen atom; and

a compound (B) which is at least one selected from the group consisting of:

a compound (b1) containing a carboxy group and a germanium atom or a tin atom, and

an ester of the compound (b1);

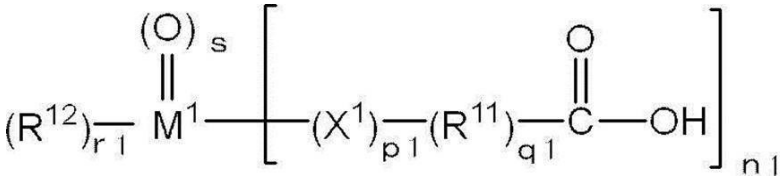
wherein the compound (a1) is at least one selected from the group consisting of:

an aliphatic amine (A-1) having a weight average molecular weight of from 10,000 to 200,000,

a compound (A-2) containing a siloxane bond (Si-O bond) and an amino group, and having a weight average molecular weight of from 130 to 50,000, and

an amine (A-3) having a ring structure and having a weight average molecular weight of from 90 to 600; and

wherein the compound (b1) is a compound represented by the following Formula (1) or the following Formula (2), or a polymer comprising at least one of a structural unit represented by the following Formula (3) or a structural unit represented by the following Formula (4):



Formula (1)

wherein, in Formula (1),

M^1 represents a germanium atom or a tin atom;

X^1 represents -S-, -S-S-, -O-, -NH-, or $-NR^{13}-$, R^{13} representing an alkyl group having from 1 to 10 carbon atoms;

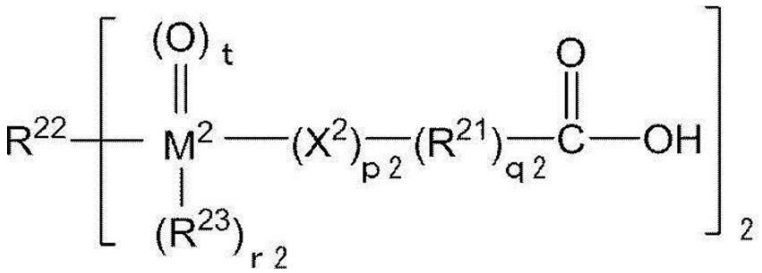
R^{11} represents an optionally substituted alkylene group having from 1 to 10 carbon atoms;

R^{12} represents a hydrogen atom, an alkyl group having from 1 to 5 carbon atoms, a hydroxy group, an alkoxy group having from 1 to 5 carbon atoms, or a halogen atom;

p1 represents 0 or 1, and q1 represents 1; and

n1 represents an integer of 1 or more, r1 represents an integer of 0 or more, and s

represents an integer of 0 or more, a sum of n1 + r1 + 2s being a valence of M^1



Formula (2)

wherein, in Formula (2),

M^2 represents a germanium atom or a tin atom;

X^2 represents -S-, -S-S-, -O-, -NH-, or $-NR^{24}$-, R^{24} representing an alkyl group having from 1 to 10 carbon atoms;

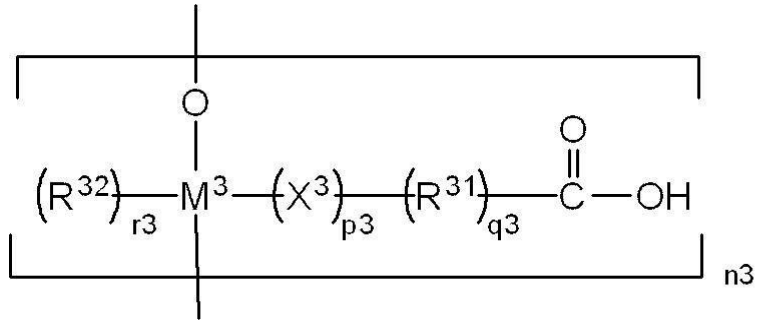
R^{21} represents an optionally substituted alkylene group having from 1 to 10 carbon atoms;

R^{22} represents a single bond, -O-, or $-NR^{25}$-, R^{25} representing an optionally substituted alkyl group having from 1 to 10 carbon atoms;

R^{23} represents a hydrogen atom, an alkyl group having from 1 to 5 carbon atoms, a hydroxy group, an alkoxy group having from 1 to 5 carbon atoms, or a halogen atom;

p2 represents 0 or 1, and q2 represents 1; and

r2 represents an integer of 0 or more, and t represents an integer of 0 or more



Formula (3)

wherein, in Formula (3),

M^3 represents a germanium atom or a tin atom;

X^3 represents -S-, -S-S-, -O-, -NH-, or $-NR^{33}$-, R^{33} representing an alkyl group having from 1 to 10 carbon atoms;

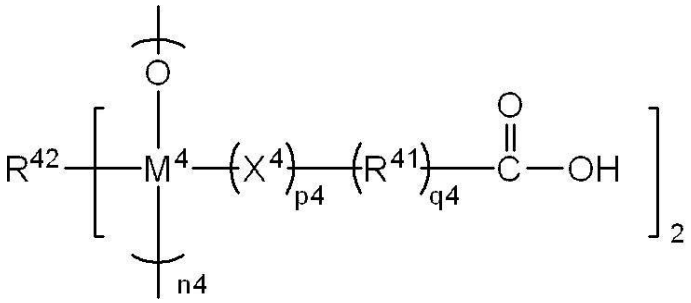
R^{31} represents an optionally substituted alkylene group having from 1 to 10 carbon atoms;

R^{32} represents a hydrogen atom, an alkyl group having from 1 to 5 carbon atoms, a hydroxy group, an alkoxy group having from 1 to 5 carbon atoms, or a halogen atom;

p3 represents 0 or 1, and q3 represents 1;

r3 represents 0 or 1; and

n3 represents an integer of 2 or more



Formula (4)

wherein, in Formula (4),

M^4 represents a germanium atom or a tin atom;

X^4 represents -S-, -S-S-, -O-, -NH-, or $-NR^{43}-$, R^{43} representing an alkyl group having from 1 to 10 carbon atoms;

R^{41} represents an optionally substituted alkylene group having from 1 to 10 carbon atoms;

R^{42} represents a single bond, -O-, or $-NR^{44}-$, R^{44} representing an optionally substituted alkyl group having from 1 to 10 carbon atoms;

p4 represents 0 or 1, and q4 represents 1; and

n4 represents an integer of 2 or more.

2. The composition for forming a metal-containing film according to claim 1, further comprising a compound (a2) which is a compound other than the compound (a1) and which contains a nitrogen atom, wherein the compound (a2) is a base (A-4) having a weight average molecular weight of from 17 to 120.

3. The composition for forming a metal-containing film according to claim 1 or 2, wherein the compound (B) has a weight average molecular weight of from 120 to 50,000.

4. The composition for forming a metal-containing film according to any one of claims 1 to 3,

wherein, in Formula (1), the sum of n1 + r1 + 2s is 4; and

wherein, in Formula (2), a sum of r2 + 2t + 2 is 4.

5. The composition for forming a metal-containing film according to any one of claims

1 to 4, further comprising an additive (C) which is an acid containing a carboxy group and having a weight average molecular weight of from 46 to 195.

6. The composition for forming a metal-containing film according to any one of claims 1 to 5, further comprising a crosslinking agent (D) having a weight average molecular weight of from 200 to 600 and containing three or more -C(=O)OX groups within a molecule, each X representing a hydrogen atom or an alkyl group having from 1 to 6 carbon atoms, and from one to six of the three or more -C(=O)OX groups each being a -C(=O)OH group.

7. The composition for forming a metal-containing film according to any one of claims 1 to 6, wherein the composition is used for forming a metal-containing film in a multilayer resist layer comprising the metal-containing film.

8. The composition for forming a metal-containing film according to any one of claims 1 to 6, wherein the composition is used for forming a metal-containing film which is an embedded dielectric film in a semiconductor device comprising the metal-containing film.

9. A method of producing the composition for forming a metal-containing film according to any one of claims 1 to 8, the method comprising:

a mixing step of mixing at least the compound (a1) and the compound (B).

10. The method of producing the composition for forming a metal-containing film according to claim 9,

wherein the composition further comprises a compound (a2) which is a compound other than the compound (a1) and which contains a nitrogen atom, wherein the compound (a2) is a base (A-4) having a weight average molecular weight of from 17 to 120, and

wherein the mixing step is a step of mixing at least a mixture of the compound (a2) and the compound (B), with the compound (a1).

11. The method of producing the composition for forming a metal-containing film according to claim 9, wherein the mixing step is a step of mixing at least: a mixture of an additive (C) which is an acid containing a carboxy group and having a weight average molecular weight of from 46 to 195, and the compound (a1), with the compound (B).

12. The method of producing the composition for forming a metal-containing film according to claim 9,

wherein the composition further comprises a compound (a2) which is a compound other than the compound (a1) and which contains a nitrogen atom, wherein the compound (a2) is a base (A-4) having a weight average molecular weight of from 17 to 120, and

wherein the mixing step is a step of mixing at least: a mixture of the compound (a2) and the compound (B), with a mixture of an additive (C) which is an acid containing a carboxy group and having a weight average molecular weight of from 46 to 195, and the compound (a1).

13. A semiconductor device comprising a metal-containing film which is an embedded dielectric film,

wherein the metal-containing film comprises the composition for forming a metal-containing film according to any one of claims 1 to 8.

14. A method of producing a semiconductor device comprising a metal-containing film which is an embedded dielectric film, the method comprising:

a step of forming the embedded dielectric film using the composition for forming a metal-containing film according to any one of claims 1 to 8.