CLAIMS

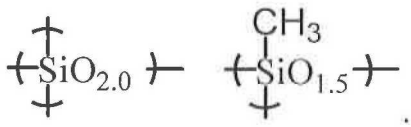
1. A resist underlayer film-forming composition for lithography having an aliphatic polycyclic structure, the composition comprising, as a silane, a hydrolysis-condensation product of a hydrolyzable silane , in which the aliphatic polycyclic structure is a structure which a hydrolyzable silane of Formula (1):

$$R^1{}_aR^2{}_bSi(R^3)_{4-(a+b)} \quad \text{Formula (1)}$$

(where R^1 is an organic group having an aliphatic polycyclic structure and bonded to a Si atom through a Si-C bond; R^2 is an alkyl group, an aryl group, a halogenated alkyl group, a halogenated aryl group, an alkoxyaryl group, an alkenyl group, or an organic group having an epoxy group, an acryloyl group, a methacryloyl group, a mercapto group, an amino group, or a cyano group, and is bonded to a silicon atom through a Si-C bond; R^3 is an ethoxy group; a is an integer of 1; b is an integer of 0 to 2; and a + b is an integer of 1 to 3) has, or a structure included in a compound added as an aliphatic polycyclic compound, an aliphatic polycyclic dicarboxylic acid, or an aliphatic polycyclic dicarboxylic acid anhydride, each optionally having a double bond, a hydroxy group, or an epoxy group,

when the aliphatic polycyclic structure is a structure which a hydrolyzable silane of Formula (1) has, the hydrolyzable silane contains a combination of a hydrolyzable silane (1-1) selected from the group consisting from tetraethoxysilane, tetramethoxysilane, methyltrialkoxysilane and phenyltrialkoxysilane with a hydrolyzable silane (1-2) selected from the group consisting from norbornene, norbornane, hetero atom-containing aliphatic polycyclic group, and norbornene, norbornane, or hetero atom-containing aliphatic polycyclic group containing ester structure, acid anhydride structure or amide structure,

the hydrolysis-condensation product contains the following two unit structures:



2. The resist underlayer film-forming composition according to claim 1, further comprising the hydrolyzable silane and/or a hydrolysis product of the hydrolyzable silane.

3. The resist underlayer film-forming composition according to claim 1 or 2, wherein R^1 in Formula (1) is an optionally substituted norbornene, an optionally substituted norbornane, a cyclic aliphatic group containing a heteroatom, or an organic group comprising an optionally substituted norbornene, an optionally substituted norbornane, or a cyclic aliphatic group containing a heteroatom.

4. The resist underlayer film-forming composition according to claim 2 or 3, wherein a substituent of R^1 in Formula (1) is a carboxylic acid anhydride group, a carboxylic acid ester group, or an oxygen atom.

5. The resist underlayer film-forming composition according to any one of claims 1 to 3, wherein the hydrolyzable silane is a combination of the hydrolyzable silane of Formula (1) and another hydrolyzable silane, the other hydrolyzable silane being at least one hydrolyzable silane selected from the group consisting of a hydrolyzable silane of Formula (2):

$$R^4{}_cSi(R^5)_{4-c} \quad \text{Formula (2)}$$

(where R^4 is an alkyl group, an aryl group, a halogenated alkyl group, a halogenated aryl group, an alkoxyaryl group, an alkenyl group, or an organic group having an epoxy group, an acryloyl group, a methacryloyl group, a mercapto group, or a cyano group, and is bonded to a silicon atom through a Si-C bond; R^5 is an alkoxy group, an acyloxy group, or a halogen group; and c is an integer of 0 to 3) and a hydrolyzable silane of Formula (3):

$$[R^6_d Si(R^7)_{3-d}]_2 Y_e \quad \text{Formula (3)}$$

(where R^6 is an alkyl group and bonded to a silicon atom through a Si-C bond; R^7 is an alkoxy group, an acyloxy group, or a halogen group; Y is an alkylene group or an arylene group; d is an integer of 0 or 1; and e is an integer of 0 or 1).

6. A resist underlayer film-forming composition comprising, as a polymer, a hydrolysis-condensation product of a hydrolyzable silane formed of a combination of the hydrolyzable silane of Formula (1) as claimed in claim 1 and the hydrolyzable silane of Formula (2) as claimed in claim 5.

7. The resist underlayer film-forming composition according to any one of claims 1 to 6, further comprising an acid as a hydrolysis catalyst.

8. The resist underlayer film-forming composition according to any one of claims 1 to 7, further comprising water.

9. A resist underlayer film obtained by applying the resist underlayer film-forming composition as claimed in any one of claims 1 to 8 onto a semiconductor substrate and baking the applied resist underlayer film-forming composition.

10. A method for manufacturing a semiconductor device, the method comprising the steps of:

applying the resist underlayer film-forming composition as claimed in any one of claims 1 to 8 onto a semiconductor substrate, and baking to form a resist underlayer film;

applying a resist composition onto the underlayer film to form a resist film;

exposing the resist film to light;

developing the resist film after the exposure to obtain a resist pattern;

etching the resist underlayer film using the resist pattern; and

processing the semiconductor substrate using the patterned resist and the patterned resist underlayer film.

11. A method for manufacturing a semiconductor device, the method comprising the steps of:

forming an organic underlayer film on a semiconductor substrate;

applying the resist underlayer film-forming composition as claimed in any one of claims 1 to 8 onto the organic underlayer film, and baking the composition to form a resist underlayer film;

applying a resist composition onto the resist underlayer film to form a resist film;

exposing the resist film to light;

developing the resist film after the exposure to obtain a resist pattern; etching the resist underlayer film using the resist pattern;

etching the organic underlayer film using the patterned resist underlayer film; and

processing the semiconductor substrate using the patterned organic underlayer film.