Claims

1. A thin film transistor substrate comprising:

a thin film transistor; and

a protective film comprising a cured product of a siloxane composition, covering said thin film transistor,

wherein said thin film transistor has a semiconductor layer made of an oxide semiconductor,

wherein said siloxane composition comprises:

a polysiloxane;

a fluorine-containing compound which is a compound represented by the following formula (M):

$$R^4Si(OR^5)_3 \quad (M)$$

wherein

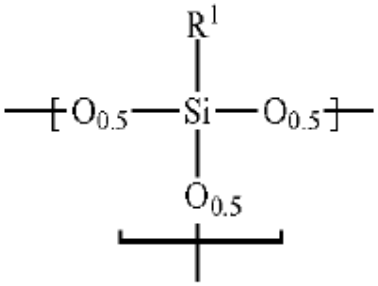
R^4 is a completely or partially fluorine-substituted hydrocarbon group having 1 to 8 carbon atoms, and

R^5 represents an alkyl group having 1 to 5 carbon atoms; and

a solvent, and

where said polysiloxane comprises a repeating unit represented by the following general formula (Ia):

(Ia)



wherein

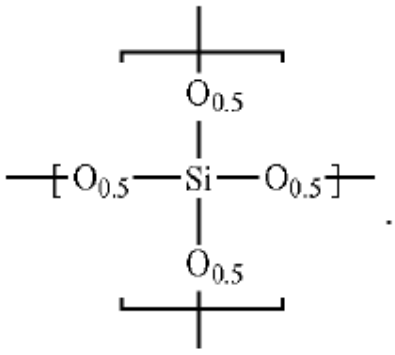
R^1 is hydrogen; a monovalent to trivalent, straight-chain, branched or cyclic, saturated or unsaturated, aliphatic hydrocarbon group having 1 to 30 carbon atoms; or a monovalent to trivalent, aromatic hydrocarbon group having 6 to 30 carbon atoms;

wherein in said aliphatic hydrocarbon group and said aromatic hydrocarbon group, one or more methylene groups are unsubstituted or substituted with an oxy group, an imide group or a carbonyl group, one or more hydrogens are unsubstituted or substituted with fluorine, a hydroxy group or an alkoxy group, and one or more carbons are unsubstituted or substituted with silicon; and

when R^1 is divalent or trivalent, R^1 connects the Si atoms to each other, which are included in a plurality of the repeating units.

2. The substrate according to claim **1**, wherein said polysiloxane further comprises a repeating unit represented by the following general formula (Ib):

(Ib)



3. The substrate according to claim **2**, wherein said polysiloxane comprises:

polysiloxane (I) obtained by hydrolysis and condensation of a silane compound represented by the following formula (ia) and a silane compound represented by the following formula (ib) in the presence of a basic catalyst:

$$R^{1'}[Si(OR^a)_3]_p \quad \text{(ia)}$$

$$Si(OR^a)_4 \quad \text{(ib)}$$

wherein

$R^{1'}$ is hydrogen; a monovalent to trivalent, linear, branched or cyclic, saturated or unsaturated, aliphatic hydrocarbon group having 1 to 30 carbon atoms; or a monovalent to trivalent, aromatic hydrocarbon group having 6 to 30 carbon atoms;

wherein in said aliphatic hydrocarbon group and said aromatic hydrocarbon group, one or more methylene groups are unsubstituted or substituted with an oxy group, an imide group or a carbonyl group, one or more hydrogens are unsubstituted or substituted with fluorine, a hydroxy group or an alkoxy group, and one or more carbons are unsubstituted or substituted with silicon; and

R^a represents an alkyl group having 1 to 10 carbon atoms,

wherein the film after prebaking of polysiloxane (I) is soluble in 5 mass % aqueous solution of tetramethylammonium hydroxide, and dissolution rate of the film is 1,000 Å/sec or less;

p is 1 to 3;

and

polysiloxane (II) obtained by hydrolysis and condensation of at least of a silane compound represented by said formula (ia) in the presence of an acidic or basic catalyst, wherein the film after prebaking of polysiloxane (II) is soluble in 2.38 mass % aqueous solution of tetramethylammonium hydroxide, and dissolution rate of the film is 100 Å/sec or more.

4. The substrate according to claim **1**, wherein said fluorine-containing compound is a photo sensitizer.

5. The substrate according to claim **4**, wherein said photosensitizer further contains a photosensitizer that is free of fluorine atom.

6. The substrate according to claim **1**, wherein in said siloxane composition, the ratio of the number of fluorine atoms derived from said fluorine-containing compound to the number of silicon atoms derived from said polysiloxane is 0.002 to 0.4.

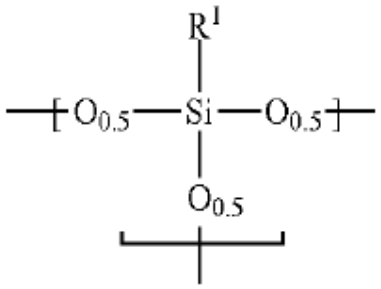
7. The substrate according to claim **1**, wherein said siloxane composition is a positive type photosensitive siloxane composition comprising at least two types of polysiloxane having different alkali dissolution rate, a diazonaphthoquinone derivative, a fluorine-containing compound and a solvent.

8. The substrate according to claim **1**, having a second protective film on said protective film.

9. A method for manufacturing the thin film transistor substrate according to claim **1**, which comprises:

a step of preparing a siloxane composition comprising polysiloxane, a fluorine-containing compound and a solvent, wherein said polysiloxane comprises a repeating unit represented by the following general formula (Ia):

(Ia)



where

R^1 is hydrogen a monovalent to trivalent, straight-chain, branched or cyclic, saturated or unsaturated, aliphatic hydrocarbon group having 1 to 30 carbon atoms; or a monovalent to trivalent, aromatic hydrocarbon group having 6 to 30 carbon atoms;

wherein in said aliphatic hydrocarbon group and said aromatic hydrocarbon group, one or more methylene groups are unsubstituted or substituted with an oxy group, an imide group or a carbonyl group, one or more hydrogens are unsubstituted or substituted with fluorine, a hydroxy group or an alkoxy group, and one or more carbons are unsubstituted or substituted with silicon; and

when R^1 is divalent or trivalent, R^1 connects the Si atoms to each other, which are included in a plurality of the repeating units;

a step of coating a thin film transistor with said siloxane composition to form a protective film precursor layer;

a step of conducting thermal curing of said protective film precursor layer to form a protective film;

a step of conducting additional heating of the formed protective film; and

a step of subjecting the thin film transistor comprising said protective film to annealing treatment.

10. The method according to claim **9**, wherein said additional heating is conducted at the same as or higher temperature than the temperature of said thermal curing.

11. The method according to claim **9**, wherein said additional heating is conducted at the same as or higher temperature than the temperature of said annealing treatment.

12. The method according to claim **9**, wherein said annealing treatment is conducted at 250° C. or higher and at 450° C. or lower.

13. The method according to claim **9**, wherein said annealing treatment is conducted in an oxygen atmosphere.

14. A siloxane composition for manufacturing a thin film transistor substrate comprising:

a polysiloxane;

a fluorine-containing compound which is a compound represented by the following formula (M):

$$R^4Si(OR^5)_3 \quad (M)$$

wherein

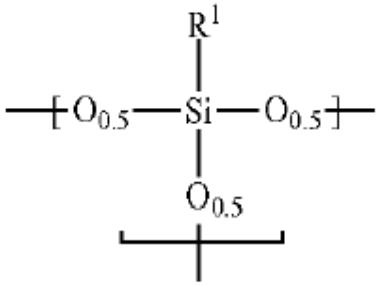
R^4 is a completely or partially fluorine-substituted hydrocarbon group having 1 to 8 carbon atoms, and

R^5 represents an alkyl group having 1 to 5 carbon atoms; and

a solvent,

wherein said polysiloxane comprises a repeating unit represented by the following general formula (Ia):

(Ia)



where

R^1 is hydrogen; a monovalent to trivalent, straight-chain, branched or cyclic, saturated or unsaturated, aliphatic hydrocarbon group having 1 to 30 carbon atoms; or a monovalent to trivalent, aromatic hydrocarbon group having 6 to 30 carbon atoms;

wherein in said aliphatic hydrocarbon group and said aromatic hydrocarbon group, one or more methylene groups are unsubstituted or substituted with an oxy group, an imide group or a carbonyl group, one or more hydrogens are unsubstituted or substituted with fluorine, a hydroxyl group or an alkoxy group, and one or more carbons are unsubstituted or substituted with silicon; and

when R^1 is divalent or trivalent, R^1 connects the Si atoms to each other, which are included in a plurality of the repeating units.

15. The composition according to claim **14**, wherein the ratio of the number of fluorine atoms derived from said fluorine-containing compound to the number of silicon atoms derived from said polysiloxane is 0.002 to 0.4.