We Claim:

1. An aqueous alkaline etching and cleaning composition comprising:

(A) at least one quaternary ammonium hydroxide; and

(B) at least one component selected from the group consisting of

(b1) water-soluble sulfonic acids and their water-soluble salts of the general formula I:

$(R^1\text{-}SO_3^-)_nX^{n+}$ (I),

(b2) water-soluble phosphonic acids and their water-soluble salts of the general formula II:

$R\text{-}PO_3^{2-}(X^{n+})_{3-n}$ (II);

(b3) water-soluble sulfuric acid esters and their water-soluble salts of the general formula III:

$(RO\text{-}SO_3^-)_nX^{n+}$ (III),

(b4) water-soluble phosphoric acid esters and their water-soluble salts of the general formula (IV):

$RO\text{-}PO_3^{2-}(X^{n+})_{3-n}$ (IV), and

(b5) water-soluble phosphoric acid esters and their water-soluble salts of the general formula (V):

$[(RO)_2PO_2^-]_nX^{n+}$ (V);

wherein the index n = 1 or 2; the variable X is selected from the group consisting of hydrogen, alkaline metal and alkaline-earth metal; the variable $R^1$ is selected from the group consisting of aliphatic moieties having 2 to 5

carbon atoms and at least one olefinically unsaturated double bond, and cycloaliphatic moieties having 4 to 6 carbon atoms and at least one olefinically unsaturated double bond; and the variable R is selected from the group consisting of aliphatic moieties having 2 to 5 carbon atoms and at least one olefinically unsaturated double bond, cycloaliphatic moieties having 4 to 6 carbon atoms and at least one olefinically unsaturated double bond, and alkylaryl moieties, wherein the aryl moieties are selected from benzene and naphthalene, the alkyl moieties are selected from methylene, ethane-diyl and propane-diyl, and the phosphorus atom in the general formula II is bonded directly and the sulfur atom in the general formula III and the phosphorus atom in the general formulas IV and V are each bonded via an oxygen atom to an aliphatic carbon atom.

2. The composition according to claim 1, characterized in that the quaternary ammonium hydroxide (A) is selected from the group consisting of tetramethylammonium hydroxide and tetraethylammonium hydroxide.

3. The composition according to claim 1 or 2, characterized in that $R^1$ is selected from vinyl, prop-1-en-1-yl, prop-2-en-1-yl (allyl) and alpha-methyl-vinyl and R is selected from vinyl, prop-1-en-1-yl, prop-2-en-1-yl (allyl), alpha-methyl-vinyl and benzyl.

4. The composition according to anyone of the claims 1 to 3, characterized in that it contains at least one acid (C) selected from the group of inorganic mineral acids and water-soluble carboxylic acids.

5. The composition according to anyone of the claims 1 to 4, characterized in that it contains at least one base (D) selected from the group of volatile inorganic and organic bases containing at least one nitrogen atom.

6. The composition according to anyone of the claims 1 to 5, characterized in that it contains at least one oxidizing agent (E) selected from the group consisting of water-soluble organic and inorganic peroxides.

7. The composition according to anyone of the claims 1 to 6, characterized in that it contains at least one metal chelating agent (F).

8. The composition according to claim 7, characterized in that the metal chelating agent (F) is selected from the group consisting of amino acid diacetates and hydroxyamino acid diacetates and their salts.

9. The composition according to anyone of the claims 1 to 8, characterized in that its pH is from 8 to 13.

10. The use of the aqueous alkaline etching and cleaning composition according to anyone of the claims 1 to 9 for the treatment of silicon substrates.

11. The use according to claim 10, characterized in that the silicon substrates are silicon wafers.

12. The use according to claim 11, characterized in that the silicon wafers are used for manufacturing devices generating electricity upon exposure to electromagnetic radiation.

13. The use according to claim 12, characterized in that the devices are photovoltaic cells and solar cells.

14. The use according to claim 13, characterized in that the solar cells are selective emitter solar cells, Metal Wrap Through (MWT) solar cells and Emitter Wrap Through (EWT) solar cells.

15. The use according to anyone of the claims 12 to 14, characterized in that the electromagnetic radiation is solar radiation.

16. The use according to anyone of the claims 10 to 15, characterized in that the aqueous alkaline cleaning and etching composition is used for the modification of the surface of the silicon substrates by etching and oxidation, the removal of phosphorus silicate glass and dead layers generated by the phosphorus emitter doping, the removal of porous silicon generated by the wet edge isolation and/or the removal of debris which has re-contaminated the surface of the silicon substrates.

17. A method for treating the surface of a silicon substrate comprising the steps of:

(1) providing an aqueous alkaline etching and cleaning composition comprising

(A) at least one quaternary ammonium hydroxide; and

(B) at least one component selected from the group consisting of

(b1a) water-soluble sulfonic acids and their water-soluble salts of the general formula I:

$(R\text{-}SO_3^-)_nX^{n+}$ (Ia),

(b2) water-soluble phosphonic acids and their water-soluble salts of the general formula II:

$R\text{-}PO_3^{2-}(X^{n+})_{3-n}$ (II),

(b3) water-soluble sulfuric acid esters and their water-soluble salts of the general formula III:

$(RO\text{-}SO_3^-)_nX^{n+}$ (III),

(b4) water-soluble phosphoric acid esters and their water-soluble salts of the general formula (IV):

$RO\text{-}PO_3^{2-}(X^{n+})_{3-n}$ (IV), and

(b5) water-soluble phosphoric acid esters and their water-soluble salts of the general formula (V):

$[(RO)_2PO_2^-]_nX^{n+}$ (V);

wherein the index n = 1 or 2; the variable X is selected from the group consisting of hydrogen, alkaline metal and alkaline-earth metal; and the variable R is selected from the group consisting of aliphatic moieties having 2 to 5 carbon atoms and at least one olefinically unsaturated double bond, cycloaliphatic moieties having 4 to 6 carbon atoms and at least one olefinically unsaturated double bond, and alkylaryl moieties, wherein the aryl moieties are selected from benzene and naphthalene, the alkyl moieties are selected from methylene, ethane-diyl and propane-diyl, and the sulfur atom and the phosphorus atom in the general formulas Ia and II are each bonded directly and the sulfur atom in the general formula III and the phosphorus atom in the general formulas IV and V are each bonded via an oxygen atom to an aliphatic carbon atom;

(2) contacting at least one major surface of the silicon substrate at least once with the said aqueous alkaline etching and cleaning composition for a time and at a temperature sufficient to obtain a clean hydrophilic surface; and

(3) removing the at least one major surface from the contact with the aqueous alkaline etching and cleaning composition.

18. The method according to claim 17, characterized in that the at least one major surface of the silicon substrate is contacted at least twice with the aqueous alkaline etching and cleaning composition.

19. The method according to claim 17 or 18, characterized in that the silicon substrate is a silicon wafer.

20. A method for manufacturing devices generating electricity upon the exposure to electromagnetic radiation comprising the steps of

(I) texturing at least one major surface of a silicon substrate with an etching composition, thereby generating a hydrophobic surface;

(II) hydrophilizing the hydrophobic surface by employing the method for treating the surface of the silicon substrate according to anyone of the claims 17 to 19;

(III) applying at least one spray-on phosphorus emitter source onto the hydrophilic surface;

(IV) heating the silicon substrate contacted with the emitter source, thereby forming phosphorus emitters within the silicon substrate or phosphorus emitters within the silicon substrate and a phosphorus silicate glass on top of the surface of the silicon substrate;

(V) modifying the upper layer of the silicon substrate containing the phosphorus emitters or removing the phosphorus silicate glass from the surface of the silicon semiconductor and, thereafter, modifying the upper layer of the silicon substrate containing the phosphorus emitters;

(VI) depositing an antireflective layer on top of the modified upper layer of the silicon substrate containing the phosphorus emitters, thereby obtaining an intermediate; and

(VII) further processing the intermediate to obtain the device.

21. The manufacturing method according to claim 20, characterized in that the method for treating the surface of a silicon substrate according to anyone of the claims 17 to 19 is employed in the process step (V).

22. The manufacturing method according to claim 20 and 21, characterized in that a wet edge isolation step is carried out before the process step (VI).

23. The manufacturing method according to claim 22, characterized in that the method for treating the surface of a silicon substrate according to anyone of the claims 17 to 19 is carried out after the wet edge isolation step.

24. The manufacturing method according to anyone of the claims 20 to 23, characterized in that the devices are photovoltaic cells and solar cells.

25. The manufacturing method according to 24, characterized in that the solar cells are selective emitter solar cells, Metal Wrap Through (MWT) solar cells and Emitter Wrap Through (EWT) solar cells.

26. A method for manufacturing devices generating electricity upon the exposure to electromagnetic radiation comprising the steps of

(I) texturing at least one major surface of a silicon substrate with an etching composition, thereby generating a hydrophobic surface;

(II) treating the hydrophobic surface of the silicon substrate in a heated atmosphere containing at least one gaseous phosphorus emitter source, thereby forming phosphorus emitters within the silicon substrate or phosphorus emitters within the silicon substrate and a phosphorus silicate glass on top of the surface of the silicon substrate;

(III) modifying the upper layer of the silicon substrate containing the phosphorus emitters or removing the phosphorus silicate glass from the surface of the silicon semiconductor and, thereafter, modifying the upper layer of the silicon substrate containing the phosphorus emitters by the method for treating the surface of a silicon substrate according to anyone of the claims 17 to 19;

(IV) depositing an antireflective layer on top of the modified upper layer of the silicon substrate containing the phosphorus emitters, thereby obtaining an intermediate; and

(V) further processing the intermediate to obtain the device.

27. The manufacturing method according to claim 26, characterized in that a wet edge isolation step is carried out before the process step (VI).

28. The manufacturing method according to claim 27, characterized in that the method for treating the surface of a silicon substrate according to anyone of the claims 17 to 19 is carried out after the wet edge isolation step.

29. The manufacturing method according to anyone of the claims 26 to 28, characterized in that the devices are photovoltaic cells and solar cells.

30. The manufacturing method according to claim 29, characterized in that the solar cells are selective emitter solar cells, Metal Wrap Through (MWT) solar cells and Emitter Wrap Through (EWT) solar cells.

IN THE CLAIMS

Claim 1: An aqueous composition, comprising:

a quaternary ammonium hydroxide; and

at least one component selected from the group consisting of a water-soluble sulfonic acid or its water-soluble salt of formula I:

$$(R^1\text{-}SO_3^-)_nX^{n+} \qquad (I),$$

a water-soluble phosphonic acid or its water-soluble salt of formula II:

$$R\text{-}PO_3^{2-}(X^{n+})_{3-n} \qquad (II),$$

a water-soluble sulfuric acid ester or its water-soluble salt of formula III:

$$(RO\text{-}SO_3^-)_nX^{n+} \qquad (III),$$

a water-soluble phosphoric acid ester or its water-soluble salt of formula IV:

$$RO\text{-}PO_3^{2-}(X^{n+})_{3-n} \qquad (IV), \text{ and}$$

a water-soluble phosphoric acid ester or its water-soluble salt of formula V:

$$[(RO)_2PO_2^-]_nX^{n+} \qquad (V),$$

wherein

the aqueous composition is alkaline;

n = 1 or 2;

X is selected from the group consisting of a hydrogen, an alkaline metal and an alkaline-earth metal;

$R^1$ is selected from the group consisting of an aliphatic moiety comprising 2 to 5 carbon atoms and an olefinically unsaturated double bond, and a cycloaliphatic moiety comprising 4 to 6 carbon atoms and an olefinically unsaturated double bond;

R is selected from the group consisting of an aliphatic moiety comprising 2 to 5 carbon atoms and an olefinically unsaturated double bond, a cycloaliphatic moiety comprising 4 to 6 carbon atoms and an olefinically unsaturated double bond, and an alkylaryl moiety, comprising an aryl moiety and an alkyl moiety,

the aryl moiety is a benzene or a naphthalene,

the alkyl moiety is a methylene, an ethane-diyl, or a propane-diyl,

a phosphorus atom in formula II is bonded directly to an aliphatic carbon atom,

a sulfur atom in formula III is bonded via an oxygen atom to an aliphatic carbon atom,

a phosphorus atom in formula IV is bonded via an oxygen atom to an aliphatic carbon atom, and

a phosphorous atom in formula V is bonded via an oxygen atom to an aliphatic carbon atom.

Claim 2: The composition according to claim 1, wherein the quaternary ammonium hydroxide is at least one selected from the group consisting of a tetramethylammonium hydroxide and a tetraethylammonium hydroxide.

Claim 3: The composition according to claim 1, wherein $R^1$ is selected from a vinyl, a prop-1-en-1-yl, a prop-2-en-1-yl and an alpha-methyl-vinyl, and R is selected from a vinyl, a prop-1-en-1-yl, a prop-2-en-1-yl, an alpha-methyl-vinyl and a benzyl.

Claim 4: The composition according to claim 1, further comprising at least one acid selected from the group consisting of an inorganic mineral acid and a water-soluble carboxylic acid.

Claim 5: The composition according to claim 1, further comprising at least one base selected from the group consisting of a volatile inorganic base comprising a nitrogen atom and an organic base comprising a nitrogen atom.

Claim 6: The composition according to claim 1, further comprising at least one oxidizing agent selected from the group consisting of a water-soluble organic peroxide and a water-soluble inorganic peroxide.

Claim 7: The composition according to claim 1, further comprising a metal chelating agent.

Claim 8: The composition according to claim 7, wherein the metal chelating agent is at least one selected from the group consisting of an amino acid diacetate, an amino acid diacetate salt, a hydroxyamino acid diacetate, and a hydroxyamino acid diacetate salt.

Claim 9: The composition according to claim 1, wherein the composition has a pH of from 8 to 13.

Claim 10: A method of treating a silicon substrate, wherein the method comprises:

contacting the silicon substrate with the composition according to claim 1.

Claim 11: The method according to claim 10, wherein the silicon substrate is a silicon wafer.

Claim 12: A method of manufacturing a device, comprising treating a silicon substrate by the method according to claim 11, wherein the device is suitable for generating electricity upon exposure to an electromagnetic radiation.

Claim 13: The method according to claim 12, wherein the device is at least one selected from the group consisting of a photovoltaic cell and a solar cell.

Claim 14: The method according to claim 13, wherein the device is a solar cell, and

the solar cell is a selective emitter solar cell, a Metal Wrap Through (MWT) solar cell, or an Emitter Wrap Through (EWT) solar cell.

Claim 15: The method according to claim 12, wherein the electromagnetic radiation is a solar radiation.

Claim 16: The method according to claim 10, wherein the contacting comprises at least one selected from the group consisting of

modifying a surface of the silicon substrate by etching and oxidation,

removing a phosphorus silicate glass and a dead layer generated by a phosphorus emitter doping,

removing a porous silicon generated by a wet edge isolation, and

removing debris which has re-contaminated the surface of the silicon substrate.

Claim 17: A method for treating the surface of a silicon substrate comprising:

contacting a first major surface of the silicon substrate at least once with an aqueous alkaline composition to obtain a clean hydrophilic surface;

removing the first major surface from the contact with the aqueous alkaline composition;

wherein

the aqueous alkaline composition comprises:

a quaternary ammonium hydroxide; and

at least one component selected from the group consisting of a water-soluble sulfonic acid or its water-soluble salt of formula Ia:

$$(R\text{-}SO_3^-)_nX^{n+} \qquad \text{(Ia)},$$

a water-soluble phosphonic acid or its water-soluble salt of formula II:

$$R\text{-}PO_3^{2-}(X^{n+})_{3-n} \qquad \text{(II)},$$

a water-soluble sulfuric acid ester or its water-soluble salt of formula III:

$$(RO\text{-}SO_3^-)_nX^{n+} \qquad \text{(III)},$$

a water-soluble phosphoric acid ester or its water-soluble salt of formula (IV):

$$RO\text{-}PO_3^{2-}(X^{n+})_{3-n} \qquad \text{(IV), and}$$

a water-soluble phosphoric acid ester or its water-soluble salt of formula (V):

$$[(RO)_2PO_2^-]_nX^{n+} \qquad \text{(V)},$$

wherein

n = 1 or 2;

X is selected from the group consisting of a hydrogen, an alkaline metal and an alkaline-earth metal;

R is selected from the group consisting of an aliphatic moiety comprising 2 to 5 carbon atoms and an olefinically unsaturated double bond, a cycloaliphatic moiety comprising 4 to 6 carbon atoms and an olefinically unsaturated double bond, and an alkylaryl moiety, comprising an aryl moiety and an alkyl moiety,

the aryl moiety is a benzene or a naphthalene,

the alkyl moiety is a methylene, an ethane-diyl or a propane-diyl,

a sulfur atom in formula Ia is bonded directly to an aliphatic carbon atom,

a sulfur atom in formula II is bonded directly to an aliphatic carbon atom,

a phosphorous atom in formula Ia is bonded directly to an aliphatic carbon atom,

and a phosphorus atom in formula II is bonded directly to an aliphatic carbon atom,

a sulfur atom in the formula III is bonded via an oxygen atom to an aliphatic carbon atom,

a phosphorus atom in formula IV is bonded via an oxygen atom to an aliphatic carbon atom, and

a phosphorous atom in formula V is bonded via an oxygen atom to an aliphatic carbon atom.

Claim 18: The method according to claim 17, further comprising:

contacting a second major surface of the silicon substrate with the aqueous alkaline composition, after the removing.

Claim 19: The method according to claim 17, wherein the silicon substrate is a silicon wafer.

Claim 20: A method for manufacturing a device, the method comprising:

texturing a major surface of a silicon substrate with an etching composition, thereby generating a hydrophobic surface;

hydrophilizing the hydrophobic surface by the method of claim 17, thereby obtaining a hydrophilic surface;

applying a spray-on phosphorus emitter source onto the hydrophilic surface;

heating the silicon substrate contacted with the emitter source, thereby obtaining a phosphorus emitter within the silicon substrate or optionally a phosphorus silicate glass on top of a surface of the silicon substrate;

modifying an upper layer of the silicon substrate comprising the phosphorus emitter, thereby obtaining a modified upper layer, or

removing the phosphorus silicate glass from a surface of the silicon substrate and, thereafter, modifying the upper layer of the silicon substrate comprising the phosphorus emitter, thereby obtaining a modified upper layer;

depositing an antireflective layer on top of the modified upper layer, thereby obtaining an intermediate; and

further processing the intermediate to obtain the device.

Claim 21: The method of claim 20, wherein the modifying comprises: texturing a first major surface of the silicon substrate with an etching composition to obtain a hydrophobic surface;

contacting the hydrophobic surface of the first major surface of the silicon substrate at least once with an aqueous alkaline composition to obtain a clean hydrophilic surface; and

removing the hydrophilic surface of the first major surface from the contact with the aqueous alkaline composition.

Claim 22: The method of claim 20, further comprising: a wet edge isolating between the modifying and the depositing.

Claim 23: The method of claim 22, further comprising after the wet edge isolating:

texturing a first major surface of the silicon substrate with an etching composition to obtain a hydrophobic surface;

contacting the hydrophobic surface of the first major surface of the silicon substrate at least once with an aqueous alkaline composition to obtain a clean hydrophilic surface; and

removing the hydrophilic surface of the first major surface from the contact with the aqueous alkaline composition.

Claim 24: The method according to claim 20, wherein the device is at least one selected from the group consisting of a photovoltaic cell and a solar cell.

Claim 25: The method according to claim 24, wherein the device is a solar cell, and

the solar cell is a selective emitter solar cell, a Metal Wrap Through (MWT) solar cell or an Emitter Wrap Through (EWT) solar cell.

Claim 26: A method for manufacturing a device,

the method comprising:

texturing a major surface of a silicon substrate with an etching composition, thereby generating a hydrophobic surface;

treating the hydrophobic surface of the silicon substrate in a heated atmosphere comprising a gaseous phosphorus emitter source, thereby obtaining a phosphorus emitter within the silicon substrate or optionally a phosphorus silicate glass on top of a surface of the silicon substrate;

modifying an upper layer of the silicon substrate comprising the phosphorus emitter or removing the phosphorus silicate glass from the surface of a silicon semiconductor and, thereafter, modifying the upper layer of the silicon substrate comprising the phosphorus emitter, in either case by the method for treating the surface of the silicon substrate according to the method of claim 17, thereby obtaining a modified upper layer;

depositing an antireflective layer on top of the modified upper layer of the silicon substrate, thereby obtaining an intermediate; and

further processing the intermediate to obtain the device.

Claim 27: The method of claim 26, further comprising: a wet edge isolating between the modifying and the depositing.

Claim 28: The method of claim 27, further comprising after the wet edge isolating:

texturing a first major surface of the silicon substrate with an etching composition to obtain a hydrophobic surface;

contacting the hydrophobic surface of the first major surface of the silicon substrate at least once with an aqueous alkaline composition to obtain a clean hydrophilic surface; and

removing the hydrophilic surface of the first major surface from the contact with the aqueous alkaline composition.

Claim 29: The method according to claim 26, wherein the device is at least one selected from the group consisting of a photovoltaic cell and a solar cell.

Claim 30: The method according to claim 29, wherein the device is a solar cell, and

the solar cell is a selective emitter solar cell, a Metal Wrap Through (MWT) solar cell or an Emitter Wrap Through (EWT) solar cell.

Claim 31: The composition according to claim 3, wherein the water-soluble sulfonic acid or its water-soluble salt of formula I is present, and $R^1$ is prop-2-en-1-yl.

Claim 32: The method according to claim 10, wherein said contacting comprises additional wet cleaning and modifying after removal of a phosphorus silicate glass.