CLAIMS

[Claim 1]

A process for cleaning a wafer having an uneven pattern at its surface, the process comprising at least the steps of:

cleaning the wafer with a cleaning liquid;

substituting the cleaning liquid retained in recessed portions of the wafer with a water-repellent liquid chemical after cleaning; and

drying the wafer,

wherein the cleaning liquid contains 80 mass% or greater of a solvent having a boiling point of 55 to 200 °C, and

wherein the water-repellent liquid chemical supplied in the substitution step has a temperature of not lower than 40 °C and lower than a boiling point of the water-repellent liquid chemical thereby imparting water repellency at least to surfaces of the recessed portions~~[[.]]~~,

the wafer is a wafer containing at least one kind of element of titanium, tungsten, aluminum, copper, tin, tantalum and ruthenium at the surfaces of the recessed portions, and

the water-repellent liquid chemical contains at least one kind selected from the group consisting of compounds represented by the following general formulas [6] to [12] and salt compounds thereof and a solvent.

R^8–P(=O)–$(OH)_g(R^9)_{2-g}$ [6]

[In the formula [6], R^8 represents a C_1-C_{18} monovalent hydrocarbon group the hydrogen elements of which may partially or entirely be replaced with a fluorine element(s). R^9 mutually independently represents a monovalent organic group having a C_1-C_{18} hydrocarbon group the hydrogen elements of which may partially or entirely be replaced with a fluorine element(s). g is an integer of from 0 to 2.]

R^{10}–C(=O)–X^4 [7]

[In the formula [7], R^{10} represents a monovalent organic group having a C_1-C_{18} hydrocarbon group, or a monovalent organic group having a

[Claim 5]

A process for cleaning a wafer having an uneven pattern at its surface, wherein the process comprises at least the steps of:

cleaning the wafer with a cleaning liquid;

substituting the cleaning liquid retained in recessed portions of the wafer with a water-repellent liquid chemical after cleaning; and

drying the wafer,

wherein the cleaning liquid contains 80 mass% or greater of a solvent having a boiling point of 55 to 200 °C, and

wherein the water-repellent liquid chemical supplied in the substitution step has a temperature of not lower than 40 °C and lower than a boiling point of the water-repellent liquid chemical thereby imparting water repellency at least to surfaces of the recessed portions,

the water-repellent liquid chemical comprises an organic solvent selected from the group consisting of hydrocarbons, esters, ethers, ketones, halogen element-containing solvents, sulfoxide-based solvents, lactone-based solvents, carbonate-based solvents, polyalcohol derivatives having no OH group, nitrogen element-containing solvents having no N–H group and a mixture liquid of these,

the wafer is a wafer containing a silicon element at the surfaces of the recessed portions, and

the water-repellent liquid chemical is one containing a silicon compound A represented by the following general formula [1] or one containing the silicon compound A and an acid or a base.

$(R^1)_aSi(H)_bX^1_{4-a-b}$ [1]

[In the formula [1], R^1 mutually independently represents a monovalent organic group having a C_1-C_{18} monovalent hydrocarbon group the hydrogen elements of which may partially or entirely be replaced with a fluorine element(s). Additionally, X^1 mutually independently represents at least one group selected from the group consisting of a monovalent functional group of which element to be bonded to a silicon element is nitrogen, a monovalent functional group of which element to be

bonded to a silicon element is oxygen, a halogen group, a nitrile group and –CO–NH–$Si(CH_3)_3$ group. a is an integer of from 1 to 3. b is an integer of from 0 to 2. The total of a and b is 1 to 3.]

[Claim 6]

A process for cleaning a wafer, as claimed in Claim 5, wherein the cleaning liquid is at least one liquid selected from the group consisting of organic solvents, water, and aqueous solutions obtained by mixing at least one kind of the organic solvents, acids, alkalis and oxidizing agents with water.

[Claim 7]

A process for cleaning a wafer, as claimed in Claim 5, wherein the water-repellent liquid chemical contains acid and that the acid is at least one selected from the group consisting of hydrogen chloride, sulfuric acid, perchloric acid, phosphoric acid, sulfonic acid represented by the following general formula [2] and its anhydride, carboxylic acid represented by the following general formula [3] and its anhydride, alkyl borate ester, aryl borate ester, boron tris(trifluoroacetate), trialkoxyboroxin, boron trifluoride and a silicon compound B represented by the following general formula [4].

$R^2S(O)_2OH$ [2]

[In the formula [2], R^2 represents a C_1-C_{18} monovalent hydrocarbon group the hydrogen elements of which may partially or entirely be replaced with a fluorine element(s).]

R^3COOH [3]

[In the formula [3], R^3 represents a C_1-C_{18} monovalent hydrocarbon group the hydrogen elements of which may partially or entirely be replaced with a fluorine element(s).]

$(R^4)_aSi(H)_dX^2_{4-c-d}$ [4]

[In the formula [4], R^4 mutually independently represents a C_1-C_{18} monovalent hydrocarbon group the hydrogen elements of which may partially or

entirely be replaced with a fluorine element(s). Additionally, X^2 mutually independently represents at least one group selected from the group consisting of chloro group, $-OCO-R^5$ (R^5 is a C_1-C_{18} monovalent hydrocarbon group the hydrogen elements of which may partially or entirely be replaced with a fluorine element(s).) and $-OS(O)_2-R^6$ (R^6 is a C_1-C_{18} monovalent hydrocarbon group the hydrogen elements of which may partially or entirely be replaced with a fluorine element(s).). *c* is an integer of from 1 to 3. *d* is an integer of from 0 to 2. The total of *c* and *d* is 1 to 3.]

[Claim 8]

A process for cleaning a wafer, as claimed in Claim 5 or 7, wherein the acid is at least one selected from the group consisting of trimethylsilyl trifluoroacetate, trimethylsilyl trifluoromethanesulfonate, dimethylsilyl trifluoroacetate, dimethylsilyl trifluoromethanesulfonate, butyldimethylsilyl trifluoroacetate, butyldimethylsilyl trifluoromethanesulfonate, hexyldimethylsilyl trifluoroacetate, hexyldimethylsilyl trifluoromethanesulfonate, octyldimethylsilyl trifluoroacetate, octyldimethylsilyl trifluoromethanesulfonate, decyldimethylsilyl trifluoroacetate, decyldimethylsilyl trifluoromethanesulfonate, dodecyldimethylsilyl trifluoroacetate and dodecyldimethylsilyl trifluoromethanesulfonate.

[Claim 9]

A process for cleaning a wafer, as claimed in any of Claims 5, 7 and 8, wherein the silicon compound A is at least one selected from the group consisting of hexamethyldisilazane, trimethylsilyl dimethylamine, trimethylsilyl diethylamine, tetramethyldisilazane, dimethylsilyl dimethylamine, dimethylsilyl diethylamine, 1,3–dibutyltetramethyldisilazane, butyldimethylsilyl dimethylamine, butyldimethylsilyl diethylamine, 1,3–dihexyltetramethyldisilazane, hexyldimethylsilyl dimethylamine, hexyldimethylsilyl diethylamine, 1,3–dioctyltetramethyldisilazane, octyldimethylsilyl dimethylamine, octyldimethylsilyl diethylamine, 1,3–didecyltetramethyldisilazane, decyldimethylsilyl dimethylamine, decyldimethylsilyl diethylamine, 1,3–didodecyltetramethyldisilazane,

dodecyldimethylsilyl dimethylamine and dodecyldimethylsilyl diethylamine.

[Claim 10]

A process for cleaning a wafer, as claimed in any of Claims 5 and 7 to 9, wherein the water-repellent liquid chemical contains a base and that the base is at least one selected from the group consisting of ammonia, N,N,N',N'-tetramethylethylenediamine, triethylenediamine, dimethylaniline, alkylamine, dialkylamine, trialkylamine, pyridine, piperazine, N-alkylmorpholine and a silicon compound C represented by the following general formula [5].

$(R^7)_e Si(H)_f X^3_{4-e-f}$ [5]

[In the formula [5], R^7 mutually independently represents a C_1-C_{18} monovalent hydrocarbon group the hydrogen elements of which may partially or entirely be replaced with a fluorine element(s). Additionally, X^3 mutually independently represents a monovalent functional group of which element to be bonded to a silicon element is nitrogen, the monovalent functional group possibly containing a fluorine element or a silicon element. *e* is an integer of from 1 to 3. *f* is an integer of from 0 to 2. The total of *e* and *f* is 1 to 3.]

[Claim 11]

A process for cleaning a wafer, as claimed in any of Claims 5 to 10, wherein the water-repellent liquid chemical supplied in the substitution step has a temperature of not lower than 70 °C and lower than a temperature represented by (the boiling point of the water-repellent liquid chemical − 10 °C).

[Claim 12]

A water-repellent liquid chemical used in a process for cleaning a wafer as claimed in any of Claims 5 to 11.

[Claim 13]

A process for cleaning a wafer having an uneven pattern at its surface,

the process comprising at least the steps of:

cleaning the wafer with a cleaning liquid;

substituting the cleaning liquid retained in recessed portions of the wafer with a water-repellent liquid chemical after cleaning; and

drying the wafer,

wherein the cleaning liquid contains 80 mass% or greater of a solvent having a boiling point of 55 to 200 °C, and

wherein the water-repellent liquid chemical supplied in the substitution step has a temperature of not lower than 40 °C and lower than a boiling point of the water-repellent liquid chemical thereby imparting water repellency at least to surfaces of the recessed portions,

wherein the wafer contains a silicon element at the surfaces of the recessed portions, and the water-repellent liquid chemical is one containing a silicon compound A represented by the following general formula [1]; or one containing the silicon compound A and an acid or a base:

$(R^1)_aSi(H)_bX^1_{4-a-b}$ [1]

[In the formula [1], R^1 mutually independently represents a monovalent organic group having a C_1-C_{18} monovalent hydrocarbon group the hydrogen elements of which may partially or entirely be replaced with a fluorine element(s). Additionally, X^1 mutually independently represents at least one group selected from the group consisting of a monovalent functional group of which element to be bonded to a silicon element is nitrogen, a monovalent functional group of which element to be bonded to a silicon element is oxygen, a halogen group, nitrile group and $-CO-NH-Si(CH_3)_3$ group. *a* is an integer of from 1 to 3. *b* is an integer of from 0 to 2. The total of *a* and *b* is 1 to 3.] and

wherein the boiling point of a component the amount of which is the largest in mass ratio among components of the water-repellent liquid chemical is not less than the boiling point of the cleaning liquid.

[Claim 14]

A process for cleaning a wafer, as claimed in Claim 13, wherein the cleaning liquid is at least one liquid selected from the group consisting of organic solvents, water, and aqueous solutions obtained by mixing at least one kind of the organic solvents, acids, alkalis and oxidizing agents with water.

[Claim 15]

A process for cleaning a wafer, as claimed in Claim 13, wherein the water-repellent liquid chemical contains acid and that the acid is at least one selected from the group consisting of hydrogen chloride, sulfuric acid, perchloric acid, phosphoric acid, sulfonic acid represented by the following general formula [2] and its anhydride, carboxylic acid represented by the following general formula [3] and its anhydride, alkyl borate ester, aryl borate ester, boron tris(trifluoroacetate), trialkoxyboroxin, boron trifluoride and a silicon compound B represented by the following general formula [4].

$R^2S(O)_2OH$ [2]

[In the formula [2], R^2 represents a C_1-C_{18} monovalent hydrocarbon group the hydrogen elements of which may partially or entirely be replaced with a fluorine element(s).]

R^3COOH [3]

[In the formula [3], R^3 represents a C_1-C_{18} monovalent hydrocarbon group the hydrogen elements of which may partially or entirely be replaced with a fluorine element(s).]

$(R^4)_cSi(H)_dX^2_{4-c-d}$ [4]

[In the formula [4], R^4 mutually independently represents a C_1-C_{18} monovalent hydrocarbon group the hydrogen elements of which may partially or entirely be replaced with a fluorine element(s). Additionally, X^2 mutually independently represents at least one group selected from the group consisting of chloro group, $-OCO-R^5$ (R^5 is a C_1-C_{18} monovalent hydrocarbon group the hydrogen elements of which may partially or entirely be replaced with a fluorine element(s).) and $-OS(O)_2-R^6$ (R^6 is a C_1-C_{18} monovalent hydrocarbon group the hydrogen elements

of which may partially or entirely be replaced with a fluorine element(s).). *c* is an integer of from 1 to 3. *d* is an integer of from 0 to 2. The total of *c* and *d* is 1 to 3.]

[Claim 16]

A process for cleaning a wafer, as claimed in Claim 13 or 15, wherein the acid is at least one selected from the group consisting of trimethylsilyl trifluoroacetate, trimethylsilyl trifluoromethanesulfonate, dimethylsilyl trifluoroacetate, dimethylsilyl trifluoromethanesulfonate, butyldimethylsilyl trifluoroacetate, butyldimethylsilyl trifluoromethanesulfonate, hexyldimethylsilyl trifluoroacetate, hexyldimethylsilyl trifluoromethanesulfonate, octyldimethylsilyl trifluoroacetate, octyldimethylsilyl trifluoromethanesulfonate, decyldimethylsilyl trifluoroacetate, decyldimethylsilyl trifluoromethanesulfonate, dodecyldimethylsilyl trifluoroacetate and dodecyldimethylsilyl trifluoromethanesulfonate.

[Claim 17]

A process for cleaning a wafer, as claimed in any of Claims 13, 15 and 16, wherein the silicon compound A is at least one selected from the group consisting of hexamethyldisilazane, trimethylsilyl dimethylamine, trimethylsilyl diethylamine, tetramethyldisilazane, dimethylsilyl dimethylamine, dimethylsilyl diethylamine, 1,3–dibutyltetramethyldisilazane, butyldimethylsilyl dimethylamine, butyldimethylsilyl diethylamine, 1,3–dihexyltetramethyldisilazane, hexyldimethylsilyl dimethylamine, hexyldimethylsilyl diethylamine, 1,3–dioctyltetramethyldisilazane, octyldimethylsilyl dimethylamine, octyldimethylsilyl diethylamine, 1,3–didecyltetramethyldisilazane, decyldimethylsilyl dimethylamine, decyldimethylsilyl diethylamine, 1,3–didodecyltetramethyldisilazane, dodecyldimethylsilyl dimethylamine and dodecyldimethylsilyl diethylamine.

[Claim 18]

A process for cleaning a wafer, as claimed in any of Claims 13 and 15 to 17, wherein the water-repellent liquid chemical contains a base and that the base is at

least one selected from the group consisting of ammonia, N,N,N',N'-tetramethylethylenediamine, triethylenediamine, dimethylaniline, alkylamine, dialkylamine, trialkylamine, pyridine, piperazine, N-alkylmorpholine and a silicon compound C represented by the following general formula [5].

$(R^7)_eSi(H)_fX^3_{4-e-f}$ [5]

[In the formula [5], R^7 mutually independently represents a C_1-C_{18} monovalent hydrocarbon group the hydrogen elements of which may partially or entirely be replaced with a fluorine element(s). Additionally, X^3 mutually independently represents a monovalent functional group of which element to be bonded to a silicon element is nitrogen, the monovalent functional group possibly containing a fluorine element or a silicon element. *e* is an integer of from 1 to 3. *f* is an integer of from 0 to 2. The total of *e* and *f* is 1 to 3.]

[Claim 19]

A process for cleaning a wafer, as claimed in any of Claims 15 to 18, wherein the water-repellent liquid chemical supplied in the substitution step has a temperature of not lower than 70 °C and lower than a temperature represented by (the boiling point of the water-repellent liquid chemical − 10 °C).

[Claim 20]

A water-repellent liquid chemical used in a process for cleaning a wafer as claimed in any of Claims 15 to 19.