CLAIMS

[Claim 1] A water repellent protective film forming agent which is able to form a protective film on a wafer that has an uneven pattern at its surface, the protective film being formed at least on surfaces of recessed portions of the wafer at the time of cleaning the wafer, the wafer being a wafer that contains a material including silicon element at least at the surfaces of the recessed portions of the uneven pattern or a wafer that contains at least one kind of material selected from the group consisting of titanium, titanium nitride, tungsten, aluminum, copper, tin, tantalum nitride and ruthenium at least at a part of the surfaces of the recessed portions of the uneven pattern, the agent comprising a silicon compound represented by the following general ~~formula [1]~~general formula [3],

$$R^2(CH_3)_2SiX \qquad [3]$$

wherein R^2 represents a C_4-C_{18} hydrocarbon group which is unsubstituted or substituted with halogen atom, X represents at least one group selected from: monovalent functional groups of which element to be bonded to the silicon element is nitrogen; monovalent functional groups of which element to be bonded to the silicon element is oxygen; and halogen groups.

~~$R^1_aSiX_{4-a}$ [1]~~

~~[In the formula, R^1 mutually independently represents a hydrogen group or a C_1-C_{18} hydrocarbon group which is unsubstituted or substituted with halogen atom, and the total number of carbons in mutually independent R^1 is not smaller than 6. X mutually independently represents at least one group selected from: monovalent functional groups of which element to be bonded to the silicon element is nitrogen; monovalent functional groups of which element to be bonded to the silicon element is oxygen; and halogen~~

~~groups. "a" is an integer of from 1 to 3.]~~

[Claim 2] A water repellent protective film forming agent which is able to form a protective film on a wafer that has an uneven pattern at its surface, the protective film being formed at least on surfaces of recessed portions of the wafer at the time of cleaning the wafer, the wafer being a wafer that contains silicon nitride at least at the surfaces of the recessed portions of the uneven pattern, the agent comprising a silicon compound represented by the following general formula [~~1~~3],

$R^2(CH_3)_2SiX$ [3]

wherein R^2 represents a C_4-C_{18} hydrocarbon group which is unsubstituted or substituted with halogen atom, X represents at least one group selected from: monovalent functional groups of which element to be bonded to the silicon element is nitrogen; monovalent functional groups of which element to be bonded to the silicon element is oxygen; and halogen groups.

~~$R^1_aSiX_{4-a}$ [1]~~

~~[In the formula, R^1 mutually independently represents a hydrogen group or a C_1-C_{18} hydrocarbon group which is unsubstituted or substituted with halogen atom, and the total number of carbons in mutually independent R^1 is not smaller than 6. X mutually independently represents at least one group selected from: monovalent functional groups of which element to be bonded to the silicon element is nitrogen; monovalent functional groups of which element to be bonded to the silicon element is oxygen; and halogen groups. "a" is an integer of from 1 to 3.]~~

[Claim 3] A water repellent protective film forming agent which is able to form a protective film on a wafer that has an uneven pattern at its surface, the protective film being formed at least on surfaces of recessed portions of the wafer at the time of cleaning the wafer, the wafer being a wafer that contains at least one kind of material selected from the group consisting of titanium, titanium nitride, tungsten, aluminum, copper, tin, tantalum nitride and ruthenium at least at the surfaces of the recessed portions of the uneven pattern, the agent comprising a silicon compound represented by the following general formula [~~1~~3],

$R^2(CH_3)_2SiX$ [3]

wherein R^2 represents a C_4-C_{18} hydrocarbon group which is unsubstituted or substituted with halogen atom, X represents at least one group selected from: monovalent functional groups of which element to be bonded to the silicon element is nitrogen; monovalent functional groups of which element to be bonded to the silicon element is oxygen; and halogen groups.

~~$R^1_aSiX_{4-a}$ [1]~~

~~[In the formula, R^1 mutually independently represents a hydrogen group or a C_1-C_{18} hydrocarbon group which is unsubstituted or substituted with halogen atom, and the total number of carbons in mutually independent R^1 is not smaller than 6. X mutually independently represents at least one group selected from: monovalent functional groups of which element to be bonded to the silicon element is nitrogen; monovalent functional groups of which element to be bonded to the silicon element is oxygen; and halogen~~

groups. "a" is an integer of from 1 to 3.]

[Claim 4] A water repellent protective film forming agent as claimed in any of claims 1 to 3, wherein the silicon compound represented by the general formula [1] is represented by the following general formula [4].

$$R^3_aR^4_bSiX_{4-a-b} \quad [4]$$

[In the formula, R^3 mutually independently represents a C_1-C_{18} hydrocarbon group where one or more hydrogen elements are substituted with a fluorine element(s). R^4 mutually independently represents a hydrogen group or a C_1-C_{18} hydrocarbon group. The total number of carbons in R^3 and R^4 in the general formula [4] is not smaller than 6. X mutually independently represents at least one group selected from: monovalent functional groups of which element to be bonded to the silicon element is nitrogen; monovalent functional groups of which element to be bonded to the silicon element is oxygen; and halogen groups. "a" is an integer of from 1 to 3, "b" is an integer of from 0 to 2, and the total of "a" and "b" is 1 to 3.]

[Claim 5] A water repellent protective film forming agent as claimed in any of claims 1 to 3, wherein the silicon compound represented by the general formula [1] is represented by the following general formula [2].

$$R^1_3SiX \quad [2]$$

[In the formula, both of R^1 and X are identical with those of the general formula [1].]

[Claim 6] A water repellent protective film forming agent as claimed in any of claims 1 to 3, wherein the silicon compound represented by the general formula [1] is represented by the following general formula [3].

~~$R^2(CH_3)_2SiX$ [3]~~

~~[In the formula, R^2 represents a C_4-C_{18} hydrocarbon group which is unsubstituted or substituted with halogen atom. X is identical with that of the general formula [1].]~~

[Claim ~~7~~4] A water repellent protective film forming agent as claimed in any of claims 1 to ~~6~~3, wherein ~~R^1, R^2 or R^3~~R^2 in the silicon compound includes five or more fluorine atoms.

[Claim ~~8~~5] A liquid chemical for forming a water repellent protective film, comprising a water repellent protective film forming agent as claimed in any of claims 1 to ~~7~~4.

[Claim ~~9~~6] A liquid chemical for forming a water repellent protective film, as claimed in claim ~~8~~5, further comprising acid.

[Claim ~~10~~7] A liquid chemical for forming a water repellent protective film, as claimed in claim ~~8~~5 or ~~9~~6, wherein the content of the water repellent protective film forming agent relative to 100 mass% of the total amount of the liquid chemical for forming a water repellent protective film is 0.1 to 50 mass%.

[Claim ~~11~~8] A method for cleaning a wafer that has an uneven pattern at its surface, the wafer being a wafer that contains a material including silicon element at least at surfaces of recessed portions of the uneven pattern or a wafer that contains at least one kind of material selected from the group consisting of titanium, titanium nitride, tungsten, aluminum, copper, tin, tantalum nitride and ruthenium at least at a part of the surfaces of the recessed portions of the uneven pattern, the method comprising the following steps of:

a cleaning step using a water-based cleaning liquid, where the

surface of the wafer is cleaned with a water-based cleaning liquid;

a water repellent protective film forming step where a liquid chemical for forming a water repellent protective film is retained at least in the recessed portions of the wafer thereby forming a water repellent protective film on the surfaces of the recessed portions;

a liquid removal step where a liquid on the surface of the wafer is removed; and

a water repellent protective film removal step where the water repellent protective film is removed from the surfaces of the recessed portions,

wherein a liquid chemical for forming a water repellent protective film, ~~as claimed in any of claims 8 to 10~~ comprising a water repellant protective film forming agent is used in the water repellent protective film forming step, the water repellant protective film forming agent comprising a silicon compound represented by the following general formula [1],

$$R^1{}_aSiX_{4-a} \quad [1]$$

wherein R1 mutually independently represents a hydrogen group or a C1-C18 hydrocarbon group which is unsubstituted or substituted with halogen atom, and the total number of carbons in mutually independent R1 is not smaller than 6, X mutually independently represents at least one group selected from: monovalent functional groups of which element to be bonded to the silicon element is nitrogen; monovalent functional groups of which element to be bonded to the silicon element is oxygen; and halogen groups. "a" is an integer of from 1 to 3.

[Claim ~~12~~9] A method for cleaning a wafer, as claimed in claim ~~11~~8, wherein the wafer is a wafer that contains silicon nitride at least at the surfaces of the recessed portions of the uneven pattern.

[Claim ~~13~~10] A method for cleaning a wafer, as claimed in claim ~~11~~8, wherein the wafer is a wafer that contains at least one kind of material selected from

the group consisting of titanium, titanium nitride, tungsten, aluminum, copper, tin, tantalum nitride and ruthenium at least at the surfaces of the recessed portions of the uneven pattern.

[Claim ~~14~~11] A method for cleaning a wafer, as claimed in any of claims ~~11~~ 8 to ~~13~~10, wherein the water repellent protective film removal step is performed by at least one treatment method selected from: irradiating the surface of the wafer with light; heating the wafer; irradiating the surface of the wafer with plasma; exposing the surface of the wafer to ozone; and subjecting the wafer to corona discharge.