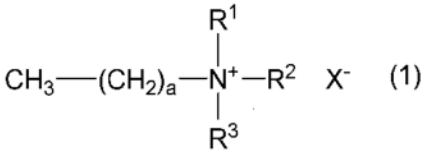
CLAIMS

1. A treatment liquid for etching a metal contained in a semiconductor wafer, wherein the treatment liquid is used in a process for forming the semiconductor wafer, the treatment liquid comprising:

(A) a hypochlorite ion; and

(B) an alkylammonium salt expressed by the following Formula (1):



(1)

,

wherein in the Formula (1),

a is an integer from 6 to 20,

R^1, R^2, and R^3 are independently a hydrogen atom, or an alkyl group with a carbon number from 1 to 20, and

X^- is a fluoride ion, a chloride ion, an iodide ion, a hydroxide ion, a nitrate ion, a phosphate ion, a sulfate ion, a hydrogen sulfate ion, a methanesulfate ion, a perchlorate ion, an acetate ion, a fluoroborate ion, or a trifluoroacetate ion.

2. The treatment liquid according to claim 1, wherein the concentration of the alkylammonium salt (B) expressed by Formula (1) is from 0.0001 to 10 mass%.

3. The treatment liquid according to claim 1 or 2, wherein the concentration of the hypochlorite ion (A) is from 0.05 to 20.0 mass%.

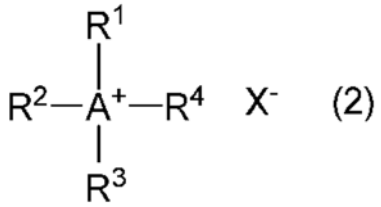
4. The treatment liquid according to any one of claims 1 to 3 comprising at least one kind of ammonium ion (C) selected from a tetramethylammonium ion, a tetraethylammonium ion, a tetrapropylammonium ion, and a tetrabutylammonium ion.

5. The treatment liquid according to any one of claims 1 to 4, wherein the pH at 25°C is greater than 7 and less than 14.0.

6. The treatment liquid according to any one of claims 1 to 5, wherein the metal contained in the semiconductor wafer is ruthenium.

7. An etching method comprising a step of bringing the semiconductor wafer into contact with the treatment liquid according to any one of claims 1 to 6.

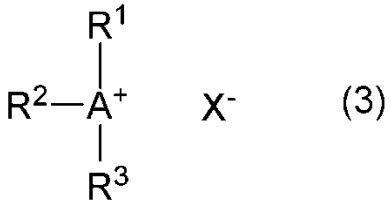
8. A treatment liquid for a semiconductor wafer, the treatment liquid comprising an onium salt consisting of an onium ion and an anion, wherein the concentration of the onium salt in the treatment liquid is from 0.0001 to 50 mass%, wherein the onium salt is a quaternary onium salt expressed by Formula (2):



(2)

, or

a tertiary onium salt expressed by Formula (3):



(3)

,

wherein in Formula (2),

A^+ is an ammonium ion, or a phosphonium ion, and

R^1, R^2, R^3, and R^4 are independently an alkyl group with a carbon number from 1 to 25, an allyl group, an aralkyl group having an alkyl group with a carbon number from 1 to 25, or an aryl group, wherein when R^1, R^2, R^3, and R^4 are alkyl groups, at least one of the alkyl groups in R^1, R^2, R^3, and R^4 has a carbon number of 2 or more, wherein at least one hydrogen in a ring of an aryl group in the aralkyl group, and the aryl group may be replaced with fluorine, chlorine, an alkyl group with a carbon number from 1 to 10, an alkenyl group with a carbon number from 2 to 10, an alkoxy group with a carbon number from 1 to 9, or an alkenyloxy group with a carbon number from 2 to 9, and wherein in these groups, at least one hydrogen may be replaced with fluorine or chlorine,

wherein in Formula (3),

A^+ is a sulfonium ion, and

R^1, R^2, and R^3 are independently an alkyl group with a carbon number from 1 to 25, an alkyl group, an aralkyl group having an alkyl group with a carbon number from 1

to 25, or an aryl group, wherein when R^1, R^2, and R^3 are alkyl groups, at least one of the alkyl groups in R^1, R^2, and R^3 has a carbon number of 2 or more, wherein at least one hydrogen in a ring of an aryl group in the aralkyl group, or the aryl group may be replaced with fluorine, chlorine, an alkyl group with a carbon number from 1 to 10, an alkenyl group with a carbon number from 2 to 10, an alkoxy group with a carbon number from 1 to 9, or an alkenyloxy group with a carbon number from 2 to 9, and wherein in these groups, at least one hydrogen may be replaced with fluorine or chlorine,

wherein in Formula (2) or (3),

X^- is a fluoride ion, a chloride ion, an iodide ion, a hydroxide ion, a nitrate ion, a phosphate ion, a sulfate ion, a hydrogen sulfate ion, a methanesulfate ion, a perchlorate ion, a chlorate ion, a chlorite ion, a hypochlorite ion, an orthoperiodate ion, a metaperiodate ion, an iodate ion, an iodite ion, a hypoiodite ion, an acetate ion, a carbonate ion, a hydrogencarbonate ion, a fluoroborate ion, or a trifluoroacetate ion, wherein the treatment liquid comprises a hypochlorite ion and the concentration of the hypochlorite ion is from 0.05 to 20.0 mass%.

~~9. The treatment liquid according to claim 8, wherein the treatment liquid comprises an oxidizing agent.~~

~~10. The treatment liquid according to claim 8 or 9, wherein the treatment liquid comprises a hypochlorite ion and the concentration of the hypochlorite ion is from 0.05 to 20.0 mass%.~~

~~11~~9. The treatment liquid according to ~~any one of~~ claim~~s~~ 8 ~~to 10~~, further comprising an organic solvent.

~~12~~10. The treatment liquid according to claim ~~11~~9, wherein the relative dielectric constant of the organic solvent is 45 or less.

~~13~~11. The treatment liquid according to claim ~~11~~ 9 or ~~12~~10, wherein the organic solvent is a sulfolane, an alkyl nitrile, a halogenated alkane, or an ether.

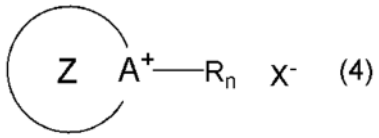
~~14~~12. The treatment liquid according to any one of claims ~~11~~ 9 to ~~13~~11, wherein the concentration of the organic solvent in the treatment liquid is 0.1 mass% or more.

~~15~~13. The treatment liquid according to any one of claims 8 to ~~14~~12, wherein the pH at 25°C is 7 or more and 14 or less.

~~16~~14. The treatment liquid according to any one of claims 8 to ~~15~~ 13 to be used for etching a semiconductor wafer containing ruthenium.

~~17~~15. Use of the treatment liquid according to any one of claims 8 to ~~15~~ 13 for etching a semiconductor wafer containing ruthenium.

~~18~~16. A treatment liquid for a semiconductor wafer, the treatment liquid comprising an onium salt consisting of an onium ion and an anion, wherein the concentration of the onium salt in the treatment liquid is from 0.0001 to 50 mass%, wherein the onium salt is an onium salt expressed by Formula (4):



wherein in Formula (4),

Z is an aromatic group or an alicyclic group that may contain a nitrogen, sulfur, or oxygen atom, and in the aromatic group or alicyclic group, the carbon or nitrogen may be replaced by

chlorine, bromine, fluorine, iodine,

at least one alkyl group with a carbon number from 1 to 15,

at least one alkenyloxy group with a carbon number from 2 to 9,

an aromatic group that may be substituted with at least one alkyl group with a carbon number from 1 to 15, or

an alicyclic group that may be substituted with at least one alkyl group with a carbon number from 1 to 15,

A is nitrogen or sulfur,

R is chlorine, bromine, fluorine, iodine, an alkyl group with a carbon number from 1 to 15, an allyl group, an aromatic group that may be substituted with at least one alkyl group with a carbon number from 1 to 15, or an alicyclic group that may be substituted with at least one alkyl group with a carbon number from 1 to 15,

X^- is an organic or inorganic anion, and

n is an integer of 1 or 2 and indicates the number of R, wherein when n is 2, R may be the same or different, and may form a ring,

wherein the treatment liquid comprises a hypochlorite ion and the concentration of the hypochlorite ion is from 0.05 to 20.0 mass%.

~~19. The treatment liquid according to claim 18, wherein the treatment liquid comprises a hypochlorite ion and the concentration of the hypochlorite ion is from 0.05 to 20.0 mass%.~~

~~20~~17. The treatment liquid according to claim ~~18~~ 16~~or 19~~, further comprising an organic solvent.

~~21~~18. The treatment liquid according to claim ~~20~~17, wherein the relative dielectric constant of the organic solvent is 45 or less.

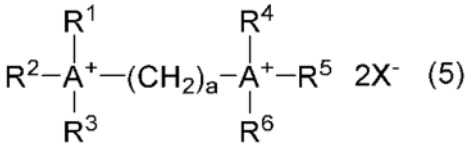
~~22~~19. The treatment liquid according to claim ~~20~~ 17 or ~~21~~18, wherein the organic solvent is a sulfolane, an alkyl nitrile, a halogenated alkane, and an ether.

~~23~~20. The treatment liquid according to any one of claims ~~20~~ 17 to ~~22~~19, wherein the concentration of the organic solvent in the treatment liquid is 0.1 mass% or more.

~~24~~21. The treatment liquid according to any one of claims ~~18~~ 16 to ~~23~~20, wherein the pH at 25°C is 7 or more and 14 or less.

~~25~~22. Use of the treatment liquid according to any one of claims ~~18~~ 16 to ~~24~~ 21 for etching a semiconductor wafer containing ruthenium.

~~26~~23. A treatment liquid for a semiconductor wafer, the treatment liquid comprising an onium salt consisting of an onium ion and an anion, wherein the concentration of the onium salt in the treatment liquid is from 0.0001 to 50 mass%, wherein the onium salt is an onium salt expressed by Formula (5):



$$R^2-\overset{R^1}{\underset{R^3}{A^+}}-(CH_2)_a-\overset{R^4}{\underset{R^6}{A^+}}-R^5 \quad 2X^- \quad (5)$$

wherein in Formula (5),

A^+ are independently an ammonium ion, or a phosphonium ion,

R^1, R^2, R^3, R^4, R^5, and R^6 are independently an alkyl group with a carbon number from 1 to 25, an allyl group, an aralkyl group having an alkyl group with a carbon number from 1 to 25, or an aryl group, wherein at least one hydrogen in a ring of an aryl group in the aralkyl group, or the aryl group may be replaced with fluorine, chlorine, an alkyl group with a carbon number from 1 to 10, an alkenyl group with a carbon number from 2 to 10, an alkoxy group with a carbon number from 1 to 9, or an alkenyloxy group with a carbon

number from 2 to 9, and wherein in these groups, at least one hydrogen may be replaced with fluorine or chlorine, and

X^- is a fluoride ion, a chloride ion, an iodide ion, a hydroxide ion, a nitrate ion, a phosphate ion, a sulfate ion, a hydrogen sulfate ion, a methanesulfate ion, a perchlorate ion, a chlorate ion, a chlorite ion, a hypochlorite ion, an orthoperiodate ion, a metaperiodate ion, an iodate ion, an iodite ion, a hypoiodite ion, an acetate ion, a carbonate ion, a hydrogencarbonate ion, a fluoroborate ion, or a trifluoroacetate ion, and a is an integer of 1 to 10,

wherein the treatment liquid comprises hypochlorite ions and the concentration of hypochlorite ions is from 0.05 to 20.0 mass%.

~~27. The treatment liquid according to claim 2624, wherein the treatment liquid comprises an oxidizing agent.~~

~~28. The treatment liquid according to claim 26 or 27, wherein the treatment liquid comprises hypochlorite ions and the concentration of hypochlorite ions is from 0.05 to 20.0 mass%.~~

~~29~~24. The treatment liquid according to ~~any one of~~ claim~~s 26~~ 23 ~~to 28~~ further comprising an organic solvent.

~~30~~25. The treatment liquid according to claim ~~29~~24, wherein the relative dielectric constant of the organic solvent is 45 or less.

~~31~~26. The treatment liquid according to claim ~~29~~24 or ~~30~~25, wherein the organic solvent is a sulfolane, an alkyl nitrile, a halogenated alkane, or an ether.

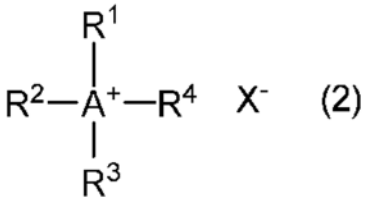
~~32~~27. The treatment liquid according to any one of claims ~~29~~ 24 to ~~31~~26, wherein the concentration of the organic solvent in the treatment liquid is 0.1 mass% or more.

~~33~~28. The treatment liquid according to any one of claims ~~26~~ 23 to ~~32~~27, wherein the pH at 25°C is 7 or more and 14 or less.

~~34.~~29. Use of the treatment liquid according to any one of claims ~~26~~ 23 to ~~33 302928~~ for etching a semiconductor wafer containing ruthenium.

~~35~~30. A method for treating a ruthenium-containing waste fluid using ~~A~~a treatment agent for a ruthenium-containing waste fluid, the treatment agent comprising an onium salt consisting of an onium ion and an anion, wherein the onium salt is

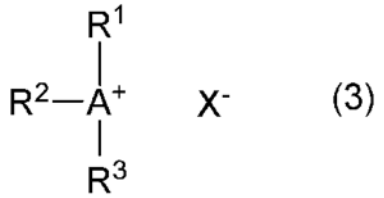
a quaternary onium salt expressed by Formula (2):



(2)

,

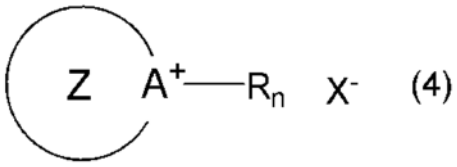
a tertiary onium salt expressed by Formula (3):



(3)

,

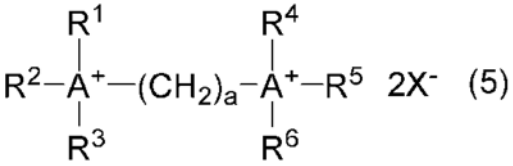
an onium salt expressed by Formula (4):



(4)

, or

an onium salt expressed by Formula (5):



(5)

,

wherein in Formula (2),

A^+ is an ammonium ion or a phosphonium ion, and

R^1, R^2, R^3, and R^4 are independently an alkyl group with a carbon number from 1 to 25, an allyl group, an aralkyl group having an alkyl group with a carbon number from 1 to 25, or an aryl group, wherein when R^1, R^2, R^3, and R^4 are alkyl groups, at least one of the alkyl groups in R^1, R^2, R^3, and R^4 has a carbon number of 2 or more, wherein at least one hydrogen in a ring of an aryl group in the aralkyl group, or the aryl group may

be replaced with fluorine, chlorine, an alkyl group with a carbon number from 1 to 10, an alkenyl group with a carbon number from 2 to 10, an alkoxy group with a carbon number from 1 to 9, or an alkenyloxy group with a carbon number from 2 to 9, and wherein in these groups, at least one hydrogen may be replaced with fluorine or chlorine,

wherein in Formula (3),

A^+ is a sulfonium ion, and

R^1, R^2, and R^3 are independently an alkyl group with a carbon number from 1 to 25, an allyl group, an aralkyl group having an alkyl group with a carbon number from 1 to 25, or an aryl group, wherein when R^1, R^2, and R^3 are alkyl groups, at least one of the alkyl groups in R^1, R^2, and R^3 has a carbon number of 2 or more, wherein at least one hydrogen in a ring of an aryl group in the aralkyl group, or the aryl group may be replaced with fluorine, chlorine, an alkyl group with a carbon number from 1 to 10, an alkenyl group with a carbon number from 2 to 10, an alkoxy group with a carbon number from 1 to 9, or an alkenyloxy group with a carbon number from 2 to 9, and wherein in these groups, at least one hydrogen may be replaced with fluorine or chlorine,

wherein in Formula (2) or (3),

X^- is a fluoride ion, a chloride ion, an iodide ion, a hydroxide ion, a nitrate ion, a phosphate ion, a sulfate ion, a hydrogen sulfate ion, a methanesulfate ion, a perchlorate ion, a chlorate ion, a chlorite ion, a hypochlorite ion, an orthoperiodate ion, a metaperiodate ion, an iodate ion, an iodite ion, a hypoiodite ion, an acetate ion, a carbonate ion, a hydrogencarbonate ion, a fluoroborate ion, or a trifluoroacetate ion,

wherein in Formula (4),

Z is an aromatic group or an alicyclic group that may contain a nitrogen, sulfur, or oxygen atom, and in the aromatic group or alicyclic group, the carbon or nitrogen may be replaced by

chlorine, bromine, fluorine, iodine,

at least one alkyl group with a carbon number from 1 to 15,

at least one alkenyloxy group with a carbon number from 2 to 9,

an aromatic group that may be substituted with at least one alkyl group with a carbon number from 1 to 15, or

an alicyclic group that may be substituted with at least one alkyl group with a carbon number from 1 to 15,

A is nitrogen or sulfur,

R is chlorine, bromine, fluorine, iodine, an alkyl group with a carbon number from 1 to 15, an allyl group, an aromatic group that may be substituted with at least one alkyl group with a carbon number from 1 to 15, or an alicyclic group that may be substituted with at least one alkyl group with a carbon number from 1 to 15,

X^- is an organic or inorganic anion, and

n is an integer of 1 or 2 and indicates the number of R, wherein when n is 2, R may be the same or different, and may form a ring,

wherein in Formula (5),

A^+ are independently an ammonium ion or a phosphonium ion,

R^1, R^2, R^3, R^4, R^5, and R^6 are independently an alkyl group with a carbon number from 1 to 25, an allyl group, an aralkyl group having an alkyl group with a carbon number from 1 to 25, or an aryl group, wherein at least one hydrogen in a ring of an aryl group in the aralkyl group, or the aryl group may be replaced with fluorine, chlorine, an alkyl group with a carbon number from 1 to 10, an alkenyl group with a carbon number from 2 to 10, an alkoxy group with a carbon number from 1 to 9, or an alkenyloxy group with a carbon number from 2 to 9; and in these groups, at least one hydrogen may be replaced with fluorine or chlorine, and

X^- is a fluoride ion, a chloride ion, an iodide ion, a hydroxide ion, a nitrate ion, a phosphate ion, a sulfate ion, a hydrogen sulfate ion, a methanesulfate ion, a perchlorate ion, a chlorate ion, a chlorite ion, a hypochlorite ion, an orthoperiodate ion, a metaperiodate ion, an iodate ion, an iodite ion, a hypoiodite ion, an acetate ion, a carbonate ion, a hydrogencarbonate ion, a fluoroborate ion, or a trifluoroacetate ion; and a is an integer of 1 to 10.

~~36. A method for treating a ruthenium-containing waste fluid using the treatment agent for a ruthenium-containing waste fluid according to claim 35.~~